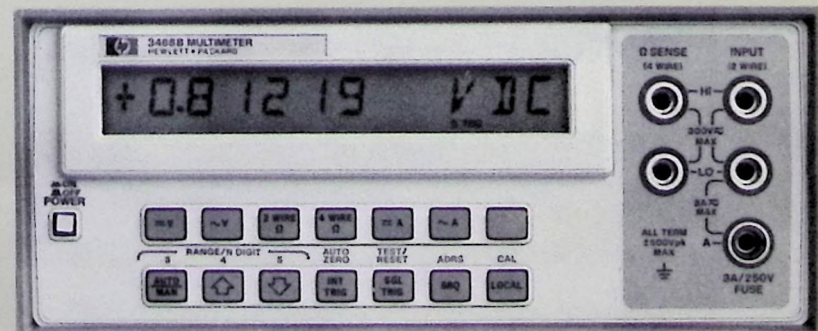
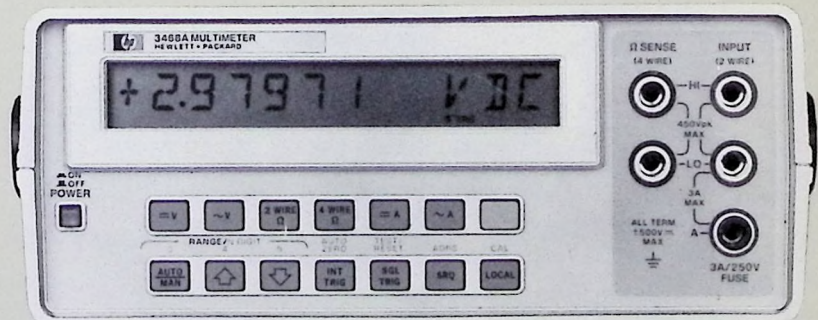


# HEWLETT-PACKARD

## HP 3468A/B Digital Multimeter

### Service Manual











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## SERVICE MANUAL

# MODEL 3468A/B DIGITAL MULTIMETER

### SERIAL NUMBERS

This manual applies to 3468As with Serial Numbers 2137A05981 and above, and to all 3468Bs with Serial Number Prefix 2231.

### IMPORTANT NOTICE

If the Serial Number or Serial Number Prefix of your instrument is lower than the ones listed on this Title Page, this manual contains information that does not apply to your instrument. Refer to the Backdating Section (Section VII) of this manual to adapt it to earlier instruments.

### RESTRICTED RIGHTS LEGEND

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3000 Hanover Street, Palo Alto, California 94304

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### Herstellerbescheinigung

Hiermit wird bescheinigt, daß das Gerät/System HP 3468A/B  
in Übereinstimmung mit den Bestimmungen von Postverfügung 1046/84 funkentstört ist.

Der Deutschen Bundespost wurde das Inverkehrbringen dieses Gerätes/Systems angezeigt und die Berechtigung zur Überprüfung der Serie auf Einhaltung der Bestimmungen eingeräumt.

### Zusatzinformation für Meß- und Testgeräte

Werden Meß- und Testgeräte mit ungeschirmten Kabeln und/oder in offenen Meßaufbauten verwendet, so ist vom Betreiber sicherzustellen, daß die Funk-Entstörbestimmungen unter Betriebsbedingungen an seiner Grundstücksgrenze eingehalten werden.

### Manufacturer's declaration

This is to certify that the equipment HP 3468A/B  
is in accordance with the Radio Interference Requirements of Directive FTZ 1046/84. The German Bundespost was notified that this equipment was put into circulation, the right to check the series for compliance with the requirements was granted.

### Additional Information for Test- and Measurement Equipment

If Test- and Measurement Equipment is operated with unscreened cables and/or used for measurements on open set-ups, the user has to assure that under operating conditions the Radio Interference Limits are still met at the border of his premises.

### NOTICE

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## CERTIFICATION

*Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.*

## WARRANTY

This Hewlett-Packard instrument product is warranted against defects in materials and workmanship for a period of one year from date of shipment [except that in the case of certain components listed in Section I of this manual, the warranty shall be for the specified period]. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by -hp-. Buyer shall prepay shipping charges to -hp- and -hp- shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to -hp- from another country.

Duration and conditions of warranty for this instrument may be superceded when the instrument is integrated into (becomes a part of) other -hp- instrument products.

Hewlett-Packard warrants that its software and firmware designated by -hp- for use with an instrument will execute its programming instructions when properly installed on that instrument. Hewlett-Packard does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

## LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HEWLETT-PACKARD SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

## EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HEWLETT-PACKARD SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

## ASSISTANCE

*Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.*

*For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.*





## **SAFETY SUMMARY**

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements. This is a Safety Class 1 instrument.

### **GROUND THE INSTRUMENT**

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

### **DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE**

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

### **KEEP AWAY FROM LIVE CIRCUITS**

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

### **DO NOT SERVICE OR ADJUST ALONE**

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

### **DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT**

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

### **DO NOT OPERATE A DAMAGED INSTRUMENT**

Whenever it is possible that the safety protection features built into this instrument have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the instrument until safe operation can be verified by service-trained personnel. If necessary, return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

### **DANGEROUS PROCEDURE WARNINGS**

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

### **WARNING**

**Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.**





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# Operating and Safety Symbols

## Symbols Used On Products And In Manuals

~ LINE

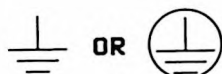
AC line voltage input receptacle.



Instruction manual symbol affixed to product. Warns and cautions the user to refer to respective instruction manual procedures to avoid personal injury or possible damage to the product.



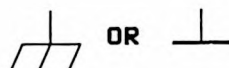
Indicates dangerous voltage – terminals connected to interior voltage exceeding 1000 volts.



Protective conductor terminal. Indicates the field wiring terminal that must be connected to earth ground before operating equipment – protects against electrical shock in case of fault.



Clean ground (low-noise). Indicates terminal that must be connected to earth ground before operating equipment – for single common connections and protection against electrical shock in case of fault.



Frame or chassis ground. Indicates equipment chassis ground terminal – normally connects to equipment frame and all metal parts.



Affixed to product containing static sensitive devices – use anti-static handling procedures to prevent electrostatic discharge damage to components.

### NOTE

### NOTE

*Calls attention to a procedure, practice, or condition that requires special attention by the reader.*

### CAUTION

### CAUTION

*Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.*

### WARNING

### WARNING

*Calls attention to a procedure, practice, or condition that could possibly cause bodily injury or death.*



# Operating and Safety Instructions

Read these instructions carefully before using the product.

Keep these instructions for future reference. Do not discard them.

For more information, visit our website at [www.example.com](http://www.example.com).

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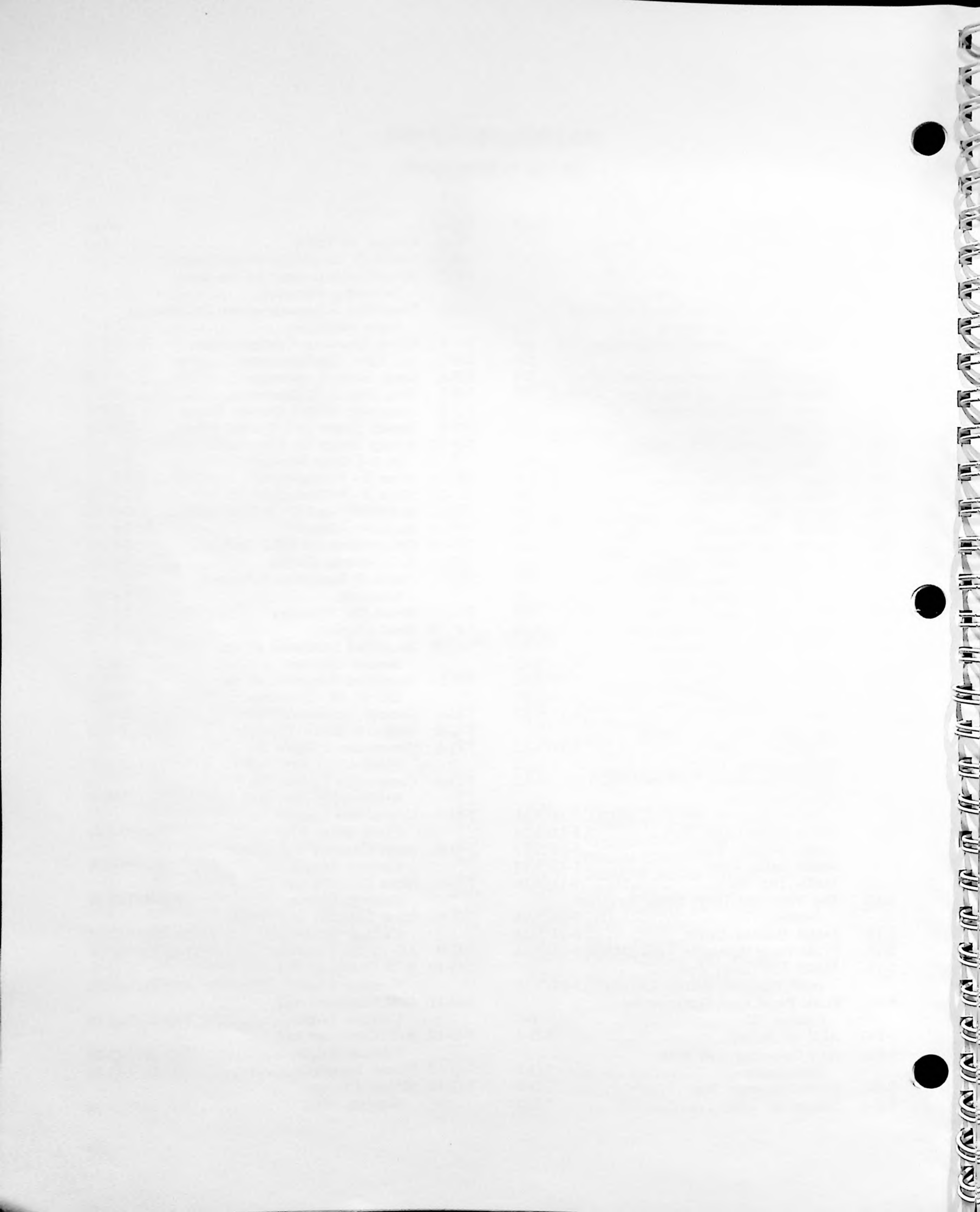


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# SECTION I

## GENERAL INFORMATION

### WARNING

*The information in this manual is for the use of Service Trained Personnel. To avoid electrical shock, do not perform any procedures in the manual or do any servicing to the 3468A/B unless you are qualified to do so.*

#### 1-1. INTRODUCTION

1-2. The information in this manual is for the Installation, Operation, Performance, Calibration, and Service of the 3468A/B Digital Multimeter. The manual is designed for the use of Service Trained Personnel. Other users should refer to the Operators Manual. This manual is separated into the following sections.

#### 1-3. Section I, General Information

1-4. A short description of the manual and introduction to the 3468A/B is in Section I. The section also lists instrument specifications and accessories.

#### 1-5. Section II, Installation Procedures

1-6. This section explains how the 3468A/B is prepared for use and includes power requirements, line voltage selection, etc. The section also explains how to connect the multimeter for remote operation.

#### 1-7. Section III, Operation

1-8. The condensed operating instructions of the 3468A/B, for the use of Service trained Personnel, is in this section. For more complete instructions, refer to the Operators Manual.

#### 1-9. Section IV, Performance Test and Calibration

1-10. The 3468A/B's Performance Test and Calibration Procedures are in Section IV. The Required Equipment Table and an abbreviated specification table are also included.

#### 1-11. Section V, Replaceable Parts

1-12. Section V lists the replaceable parts of the 3468A/B. It also includes pictures and illustrations of chassis and mechanical parts.

#### 1-13. Section VI, Backdating

1-14. This section has information for adapting the manual to 3468A/B's with serial numbers below the ones shown on the title page.

#### 1-15. Section VII, Service

1-16. The 3468A/B's Troubleshooting Procedures, Theory Of Operation, and Schematics are in Section VII. The troubleshooting information is in the form of Service Groups which are symptoms oriented (i.e., what is the failure). The complete theory of operation is in Service Group F and the Schematics are in Service Group G (last group).

#### 1-17. Appendix A

1-18. The appendix has a condensed description of the HP-IL (Hewlett-Packard Interface Loop).

#### 1-19. DESCRIPTION

1-20. The -hp- Model 3468A/B is a versatile multimeter with dc and ac volts, dc and ac current, and resistance measurement capabilities. The multimeter is excellent for bench use, and since it is remotely programmable, it can be used in measurement systems. A feature of the instrument is that the reading can be displayed in either 5 1/2, 4 1/2, or 3 1/2 digits. Other features are Autozero (for good stability), and an AlphaNumeric Liquid Crystal Display.

1-21. Another excellent feature is Electronic Calibration. No mechanical adjustments are necessary to calibrate the 3468A/B.

#### 1-22. SPECIFICATIONS

1-23. Specifications of the 3468A/B are the performance characteristics of the multimeter which are certified. The specifications are listed in Table 1-1 and Table 4-1 (in Section IV). They are the performance standards or limits against which the multimeter can be tested.

#### 1-24. INSTRUMENT AND MANUAL IDENTIFICATION

1-25. Instrument Identification is by a serial number located on the multimeter's rear panel. Hewlett-Packard uses a two-part serial number with the first part (prefix) identifying a series of instruments and the second part (suffix) identifies a particular instrument within a series. An -hp- assigned alpha character between the prefix and



Table 1-1. Specifications

**DC VOLTAGE****Input Characteristics:**

Range	Maximum Reading (5½ Digit)	Resolution		
		5½ Digit	4½ Digit	3½ Digit
.3V	±.301000V	1μV	10μV	100μV
3V	±3.01000V	10μV	100μV	1mV
30V	±30.1000V	100μV	1mV	10mV
300V	±301.000V	1mV	10mV	100mV

**Input Resistance:**

.3V, 3V ranges:  $> 10^{10}\Omega$   
 30V, 300V ranges:  $10M\Omega \pm 1\%$

**Maximum Input Voltage: (non-destructive)**

Hi to Lo: 301 Vrms or 450V peak  
 Hi or Lo to Earth Ground:  $\pm 500V$  peak

**Measurement Accuracy:**

$\pm$  (% of reading + number of counts)  
 Auto-zero ON

**5½ Digit Mode:**

Range	Cal. Temp $\pm 1^\circ C$	Cal. Temp. $\pm 5^\circ C$	
	24 Hours	90 Day	1 Year
.3V	0.005 + 4	0.009 + 5	0.02 + 5
3V	0.0035 + 2	0.007 + 2	0.018 + 2
30V	0.005 + 3	0.009 + 3	0.02 + 3
300V	0.0055 + 2	0.009 + 2	0.02 + 2

**4½ and 3½ Digit Mode:**

Accuracy is the same as 5½ digit mode for % of reading; use 1 count for number of counts.

The Cal. Temp. (Calibration Temperature) is the temperature of the environment where the 3468A/B was calibrated. Calibration should be performed with the temperature of the environment between  $20^\circ C$  and  $30^\circ C$ .

**Auto-Zero Off:**

(5½ digit) for a stable environment ( $\pm 1^\circ C$ ), for  $< 24$  hrs., add 11 counts to accuracy specification for .3V and 30V ranges, 3 counts for 3V and 300V ranges. For 4½ or 3½ digits, multiply counts by 0.1.

**Temperature Coefficient:**

$0^\circ C$  to (Cal. Temp.  $- 5^\circ C$ ), (Cal. Temp.  $+ 5^\circ C$ ) to  $55^\circ C$   
 5½ digit display, auto-zero ON  
 $\pm$  (% of reading + number of counts)/ $^\circ C$

Range	Temperature Coefficient
.3V, 30V	0.0008 + .5
3V, 300V	0.0007 + .05

**Noise Rejection:**

In dB, with  $1k\Omega$  imbalance in Lo lead. AC rejection for 50, 60Hz  $\pm 0.1\%$ . Auto-zero ON.

Display	AC NMR	AC ECMR	DC CMR
5½ digits	80	150	140
4½ digits	59	130	140
3½ digits	0	70	140

**Maximum Reading Rates: (readings/sec)**

First reading is correct within .1 count of final value, when on correct range, triggered coincident with step input.

The reading rates are dependent on the speed of the controller being used.

Line Frequency	Auto Zero	Resolution		
		3½ Digits	4½ Digits	5½ Digits
60Hz	Off	32	21	3.7
	On	25	13.4	2
50Hz	Off	32	19	3.1
	On	25	12	1.7

**Maximum Reading Rate with 41CV:**

2 readings/sec

**Display Rate: (readings/sec)**

For 50 or 60 Hz operation.

	5½ Digits	4½ or 3½ Digits
Auto Zero off	4	4
Auto Zero On	2	4

**Resistance (2-wire  $\Omega$ , 4-wire  $\Omega$ )****Input Characteristics:**

Range	Maximum Reading (5½ Digit)	Resolution		
		5½ Digit	4½ Digit	3½ Digit
300 $\Omega$	301.000 $\Omega$	1m $\Omega$	10m $\Omega$	100m $\Omega$
3 k $\Omega$	3.01000 k $\Omega$	10m $\Omega$	100m $\Omega$	1 $\Omega$
30 k $\Omega$	30.1000 k $\Omega$	100m $\Omega$	1 $\Omega$	10 $\Omega$
300 k $\Omega$	301.000 k $\Omega$	1 $\Omega$	10 $\Omega$	100 $\Omega$
3M $\Omega$	3.01000M $\Omega$	10 $\Omega$	100 $\Omega$	1 k $\Omega$
30M $\Omega$	30.1000M $\Omega$	100 $\Omega$	1 k $\Omega$	10 k $\Omega$

**Input Protection: (non-destructive)**

Hi source to Lo source:  $\pm 350V$  peak  
 Hi sense to Lo sense:  $\pm 350V$  peak  
 Hi or Lo to Earth Ground:  $\pm 500V$  peak

**Measurement Accuracy:**

$\pm$  (% of reading + number of counts)  
 Auto-zero ON. 4-wire ohms.

Table 1-1. Specifications (Cont'd)

**Resistance (2-wire  $\Omega$ , 4-wire  $\Omega$ ) (Cont'd)****5½ Digit Mode:**

Range	Cal. Temp $\pm 1^\circ\text{C}$	Cal. Temp. $\pm 5^\circ\text{C}$	
	24 Hours	90 Day	1 Year
300 $\Omega$	0.0045 + 4	0.012 + 5	0.017 + 5
3k – 300k $\Omega$	0.0035 + 2	0.011 + 2	0.016 + 2
3M $\Omega$	0.0052 + 2	0.011 + 2	0.016 + 2
30M $\Omega$	0.036 + 2	0.066 + 2	0.078 + 2

**2-Wire Ohms Accuracy:**

Same as 4-wire ohms, except add a maximum of 100m $\Omega$  off-set.

**Auto-Zero Off:**

(5½ digit) for a stable environment ( $\pm 1^\circ\text{C}$ ), for < 24 hrs., add 11 counts to accuracy specification for 300 $\Omega$  range 3 counts for 3k $\Omega$  through 300k $\Omega$  ranges, 8 counts for 3M $\Omega$  range, and 33 counts for 30M $\Omega$  range.

**Temperature Coefficient:**

0 $^\circ\text{C}$  to (Cal. Temp.  $- 5^\circ\text{C}$ ), (Cal. Temp.  $+ 5^\circ\text{C}$ ) to 55 $^\circ\text{C}$   
 5½ digit display, auto-zero ON  
 $\pm$  (% of reading + number of counts)/ $^\circ\text{C}$

Range	Temperature Coefficient
300 $\Omega$	0.0009 + 0.5
3k – 300k $\Omega$	0.0009 + 0.05
3M $\Omega$	0.0021 + 0.05
30M $\Omega$	0.021 + 0.05

**Current Through Unknown:**

Range:	300 $\Omega$	3k $\Omega$	30k $\Omega$	300k $\Omega$	3M $\Omega$	30M $\Omega$
Current:	1mA	1mA	100 $\mu\text{A}$	10 $\mu\text{A}$	1 $\mu\text{A}$	100nA

**Maximum Open Circuit Voltage:**

6.5V

**Maximum Reading Rates:**

Same as dc volts, except for 3M $\Omega$  and 30M $\Omega$  ranges. For 3M $\Omega$  range, add 20ms; for 30M $\Omega$  range, add 200ms per reading.

**AC VOLTAGE (true rms responding)****Input Characteristics:**

Range	Maximum Reading (5½ Digit)	Resolution		
		5½ Digit	4½ Digit	3½ Digit
.3V	.301000V	1 $\mu\text{V}$	10 $\mu\text{V}$	100 $\mu\text{V}$
3V	3.01000V	10 $\mu\text{V}$	100 $\mu\text{V}$	1mV
30V	30.1000V	100 $\mu\text{V}$	1mV	10mV
300V	301.000V	1mV	10mV	100mV

**Input Impedance:**

1M $\Omega \pm 1\%$  shunted by < 60pF

**Maximum Input Voltage: (non-destructive)**

Hi to Lo: 301Vrms or 450V peak  
 Hi or Lo to Earth Ground:  $\pm 500\text{V}$  peak

**Measurement Accuracy:**

$\pm$  (% of reading + number of counts)

Auto-zero ON. 5½ digit display. Accuracy is specified for sine-wave inputs only, > 10% of full scale.

1 Year, Cal. Temp.  $\pm 5^\circ\text{C}$

Frequency	Ranges		
	.3V	3V, 30V	300V
20Hz–50Hz	1.14 + 163	1.14 + 102	1.18 + 102
50Hz – 100Hz	0.46 + 163	0.46 + 103	0.5 + 102
100Hz – 20kHz	0.29 + 163	0.26 + 102	0.33 + 102
20kHz – 50kHz	0.56 + 247	0.41 + 180	0.55 + 180
50kHz – 100kHz	1.74 + 882	1.05 + 825	1.26 + 825
100kHz – 300kHz		10.1 + 3720 (30V range only)	

**Auto-Zero Off:**

(5½ digits) for a stable environment ( $\pm 1^\circ\text{C}$ ), for < 24 hrs., add 10 counts to accuracy specifications for all ranges.

**Temperature Coefficient:**

0 $^\circ\text{C}$  to (Cal. Temp.  $- 5^\circ\text{C}$ ), (Cal. Temp.  $+ 5^\circ\text{C}$ ) to 55 $^\circ\text{C}$ ,  
 5½ digit display, auto-zero ON.

For frequencies < 20kHz,  $\pm$  (0.016% of reading + 10 counts)/ $^\circ\text{C}$

For frequencies > 20kHz,  $\pm$  (0.04% of reading + 10 counts)/ $^\circ\text{C}$

**Crest Factor:**

> 4:1 at full scale.

**Common Mode Rejection:**

With 1k $\Omega$  imbalance in Lo lead, > 70dB, dc to 60Hz.

**Maximum Reading Rates: (readings/sec)**

First reading is correct within 70 counts of final value, when on correct range, triggered coincident with step input. Add 0.6 seconds for each range change.

For 50 or 60Hz operation, auto-zero ON or OFF.

3½ or 4½ digits: 1.4 readings/sec

5½ digits: 1.0 readings/sec

**DC CURRENT****Input Characteristics:**

Range	Maximum Reading (5½ Digit)	Resolution		
		5½ Digit	4½ Digit	3½ Digit
3A	$\pm 3.01000\text{A}$	10 $\mu\text{A}$	100 $\mu\text{A}$	1mA

**Maximum Input: (non-destructive)**

3A from < 250V source; fuse protected

**Measurement Accuracy:**

$\pm$  (% of reading + number of counts)

Auto-zero ON. 5½ digit display.

Range	Cal. Temp. $\pm 5^\circ\text{C}$	
	90 Days	1 Year
3A, < 1A input	0.14 + 6	0.17 + 6
3A, > 1A input	1.0 + 30	1.0 + 30



Table 1-1. Specifications (Cont'd)

**DC CURRENT (Cont'd)****Auto-Zero Off:**

(5½ digit) for a stable environment ( $\pm 1^\circ\text{C}$ ), for < 24 hrs., add 11 counts to accuracy specification for 5½ digit mode.

**Temperature Coefficient:**

0°C to (Cal. Temp.  $-5^\circ\text{C}$ ), (Cal. Temp.  $+5^\circ\text{C}$ ) to 55°C  
 5½ digit display, auto-zero ON  
 $\pm (0.012 \text{ of reading} + 0.5 \text{ counts})/^\circ\text{C}$

**Maximum Burden at Full Scale:**

1V

**Maximum Reading Rates:**

Same as dc volts

**AC CURRENT (true rms responding)****Input Characteristics:**

Range	Maximum Reading (5½ Digit)	Resolution		
		5½ Digit	4½ Digit	3½ Digit
.3A	.301000A	1µA	10µA	100µA
3A	3.01000A	10µA	100µA	1mA

**Maximum Input: (non-destructive)**

3A from < 250V source; fuse protected

**Measurement Accuracy:**

$\pm$  (% of reading + number of counts)  
 Auto-zero ON. 5½ digit display. Accuracy specified for sine-wave inputs only > 10% of full scale.  
 1 YEAR, CAL. TEMP.  $\pm 5^\circ\text{C}$

Frequency	Ranges	
	300mA	3A
20Hz–50Hz	1.77 + 163	2.5 + 163
50Hz–1kHz	1.1 + 163	1.8 + 163
1kHz–10kHz	1.0 + 163	1.7 + 163
10kHz–20kHz	1.14 + 163	1.84 + 163

**Auto-zero Off:**

(5½ digits) for a stable environment ( $\pm 1^\circ\text{C}$ ), for < 24 hrs., add 10 counts to accuracy specification.

**Temperature Coefficient:**

0°C to (Cal. Temp.  $-5^\circ\text{C}$ ), (Cal. Temp.  $+5^\circ\text{C}$ ) to 55°C.  
 5½ digits, auto-zero ON.  
 $\pm (0.021\% \text{ of reading} + 10 \text{ counts})/^\circ\text{C}$

**Maximum Burden at Full Scale:**

1V

**Crest Factor:**

> 4:1 at full scale

**Maximum Reading Rates:**

Same as ac volts

**GENERAL INFORMATION****Operating Temperature:**

0 to 55°C

**Humidity Range:**

95% R.H., 0 to 40°C

**Storage Temperature:**

$-40^\circ\text{C}$  to  $75^\circ\text{C}$   
 except for battery option,  $-40^\circ\text{C}$  to  $+65^\circ\text{C}$

**Warm-up Time:**

1 hr. to meet all specifications.

**Integration Time:**

Number of Digits	Line Frequency	
	50Hz	60Hz
5½	200ms	166.7ms
4½	20ms	16.67ms
3½	2ms	2ms

**Power:**

AC Line 48–440Hz; 86–250V, (see configuration)

**Battery: (Option 001)**

Rechargeable lead-acid; minimum continuous operation for 5 hours at 25°C; recharge time is 16 hours with 3468A off and 36 hours with 3468A on.

**Maximum Power:**

< 13 VA

**Size:**

98.4mm H x 238.1mm W x 276.2mm D  
 (3.88 in H x 9.38 in W x 10.88 in D)

**Weight:**

3468A/B -2.1 kg (4.63 lbs.)  
 3468A/B with Option 001 - 3.1 kg (6.83 lbs.)

suffix identifies the country in which the 3468A/B was manufactured.

1-26. This manual applies to instruments with the serial number identified on the title page. Updating of the manual is accomplished either by a change sheet or revised manual.

### 1-27. OPTIONS

1-28. The following options are available for the 3468A/B.

- Option 001: add Rechargeable Battery Pack
- Option 315: set for 100V, 50Hz Power Source
- Option 316: set for 100V, 60Hz Power Source
- Option 325: set for 120V, 50Hz Power Source
- Option 326: set for 120V, 60Hz Power Source
- Option 335: set for 220V, 50Hz Power Source
- Option 336: set for 220V, 60Hz Power Source
- Option 345: set for 240V, 50Hz Power Source
- Option 346: set for 240V, 60Hz Power Source

Option 908: Rack Mount Kit for HP3468B

Option 910: additional set of Operators and Service Manuals

### 1-29. ACCESSORIES AVAILABLE

1-30. The following is a list of available accessories for the 3468A/B.

Accessory No.	Description
10023A	Temperature Probe
11000A	Test leads, dual banana both ends
11002A	Test leads, dual banana to dual alligator
11003A	Test leads, dual banana to probe and alligator
11096B	RF Probe
34111A	High Voltage Probe
34118A	Test Leads, dual banana to probes with safety guard rings
82167A	HP-IL Cable (2 each)





## SECTION II INSTALLATION

### 2-1. INTRODUCTION

2-2. This section of the manual has the necessary information and instructions to install and interface the -hp- Model 3468A/B Digital Multimeter. Included are initial inspection procedures, power requirements, environmental information, and instructions for repacking the instrument for shipment. The information in this section is for Service Trained Personnel.

#### WARNING

*The information in this manual is for the use of Service Trained Personnel. To avoid electrical shock, do not perform any procedures in this manual or do any servicing to the 3468A/B, unless you are qualified to do so.*

### 2-3. INITIAL INSPECTION

2-4. The 3468A/B was carefully inspected both mechanically and electrically before shipment. It should be free of marks or scratches and in perfect electrical order upon receipt. The multimeter should be inspected for any damage that may have occurred in transit. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment has been checked for completeness and the instrument has been mechanically and electrically checked. Procedures for checking the electrical performance of the 3468A/B are in Section IV. If there is mechanical damage, the contents are incomplete, or the multimeter does not pass its Performance Test, notify the nearest Hewlett-Packard Office (a list of the -hp- Sales/Service offices is located at the back of the manual). If the shipping container is damaged or the cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Save the shipping material for the carrier's inspection.

### 2-5. POWER REQUIREMENTS

2-6. The 3468A/B requires a power source of 100V, 120V, 220V, or 240V ac (-10%, +5%), 48Hz to 440Hz single phase. The maximum power consumption is 13VA. For the 3468A/B to meet its noise and normal mode rejection specifications, the multimeter must be operated using a line frequency of either 50Hz or 60Hz (dependent on option). A listing of the 3468A/B's power options, the corresponding power line voltage, and line frequency are as follows:

Option	Voltage and Frequency	Option	Voltage and Frequency
Option 315	100V ac @ 50Hz	Option 335	220V ac @ 50Hz
Option 316	100V ac @ 60 Hz	Option 336	220V ac @ 60 Hz
Option 325	120V ac @ 50 Hz	Option 345	240V ac @ 50 Hz
Option 326	120V ac @ 60 Hz	Option 346	240V ac @ 60 Hz

#### CAUTION

*Before connecting power to the 3468A/B, make sure the power source matches the power requirements of the multimeter, as marked on the option label affixed to the rear panel. If the instrument is incompatible with the available power source, go to Paragraph 2-7 to reconfigure the multimeter.*

### 2-7. Line Frequency and Line Voltage Selection

2-8. The Power Line Frequency can be selected from the switch behind the 3468A/B's rear panel. Locate the switch, shown in Figure 2-1, and set the switch to the desired power frequency (50Hz or 60Hz), as shown in the figure. To set the 3468A/B to the correct power line voltage, the instrument has to be first disassembled. Then, make sure that the instrument is set to the correct power line voltage. If it is, reassemble the 3468A/B. If not, select the jumper for the correct voltage and then reassemble the instrument. The procedures to disassemble the 3468A/B, select the correct jumper, and reassemble the 3468A/B are as follows:

#### NOTE

*The rear panel switches can be externally set without instrument disassembly by doing the following:*

1. Bring the rear panel under a light source to locate the switches inside the instrument. Determine which switch you want changed.
2. Insert a small blade screwdriver or awl through the appropriate opening on the rear panel.
3. Place the screwdriver or awl below or above the switch rocker, dependent on the position of the rocker. Push the rocker up or down.

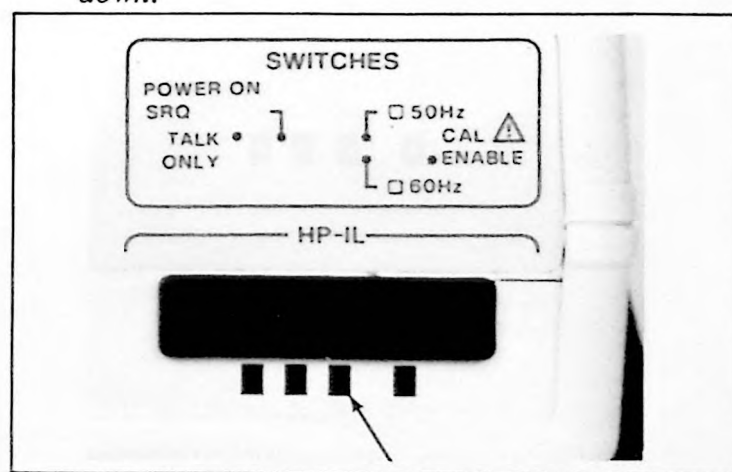


Figure 2-1. 3468A/B Power Frequency Switch



**2-9. 3468A/B Disassembly.** Do the following to disassemble the 3468A/B.

**CAUTION**

*The instrument contains CMOS Integrated Circuits which are susceptible to failures due to static discharge. It is especially important that grounded tools and wrist straps be used when handling the printed circuit boards.*

a. Disconnect the 3468A/B's Power Cord and turn the instrument off. Then do the following:

1. If the instrument is a 3468A (see next step for a 3468B), place the instrument into the inverted position. Locate and loosen the four screws at the bottom of the instrument. (Loosen the screws only enough to remove the top cover.) Continue with step b.

2. If the instrument is a 3468B (see previous step for a 3468A), place the instrument into the inverted position and locate the two rear feet (see Figure 2-2). Then remove the two rear feet. To remove a foot, lift up the tab on the foot and then push the foot toward the front of the instrument. Then lift the foot away from the instrument and remove it. Once the rear feet are removed, locate and loosen the four

screws at the bottom of the instrument, as shown in Figure 2-2. (Loosen the screws only enough to remove the top cover.) Continue with step b.

b. Carefully return the 3468A/B to the upright position with the front panel facing you.

c. If the 3468A/B does not have the optional battery circuitry (Option 001), lift the top cover up and away from the instrument and set it aside. Continue with step e.

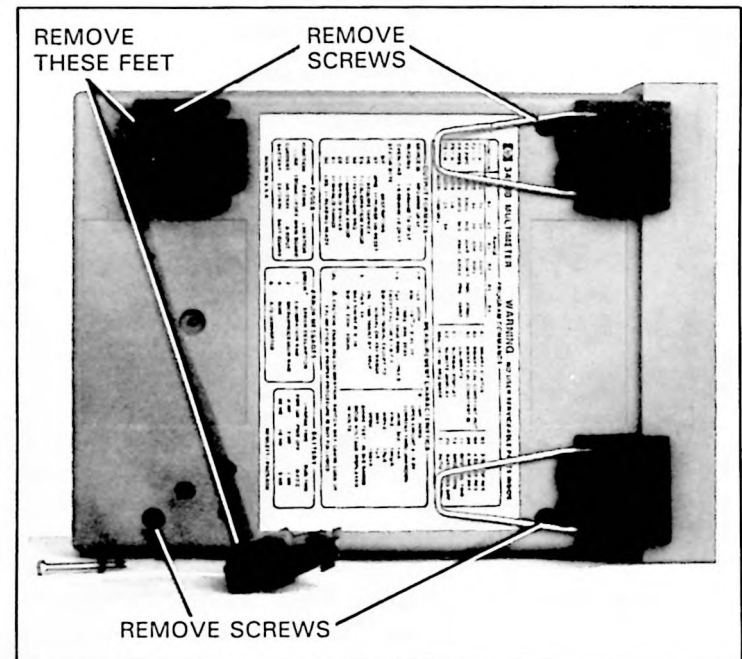


Figure 2-2. 3468B Bottom View

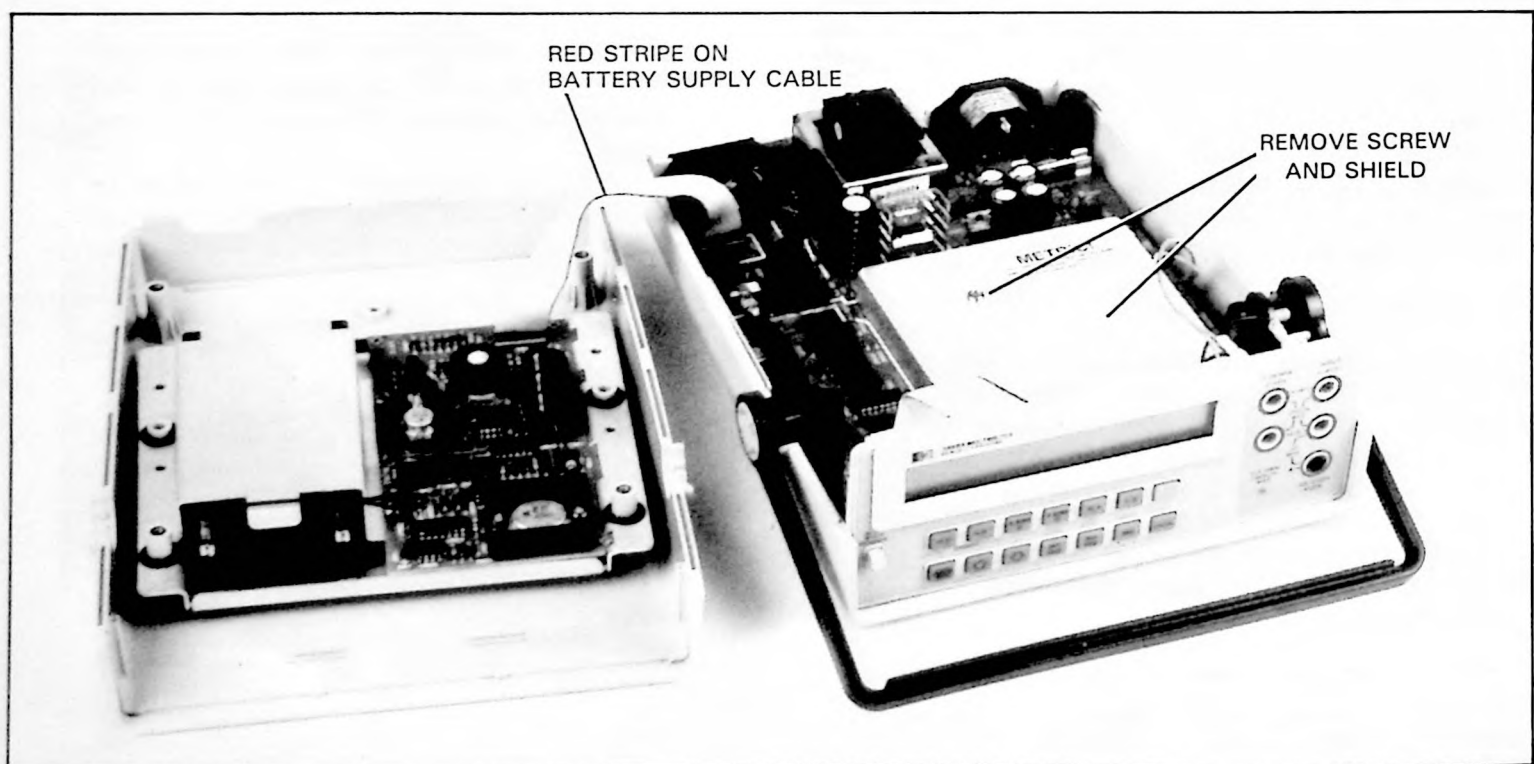


Figure 2-3. Top Cover Removed (Model 3468A shown)

d. If the 3468A/B has the optional battery circuitry, lift the top cover assembly up approximately one inch and then place it to the left of the instrument (in an inverted position), as shown in Figure 2-3. Locate the battery cable which connects the battery printed circuit board to the main printed circuit board. Note that the cable is plugged into the main printed circuit board with the red stripe on the cable toward the outside of the instrument case.

e. Locate the power line select jumper. It is located on the 3468A/B's main printed circuit board at the right side of the power transformer (see Figure 2-5). If the jumper is in the correct position, go to paragraph 2-11 to reassemble the 3468A/B. If the jumper needs to be changed, continue with paragraph 2-10.

**2-10. Power Line Jumper Selection.** If the jumper has to be changed, further disassembly of the instrument is required. Do the following:

### CAUTION

*To prevent leakage paths on the main printed circuit board, hold and/or handle the board by the power transformer only.*

a. Refer to Figure 2-3 and locate the inner shield on the 3468A/B's main printed circuit board. Loosen and remove the mounting screw on the shield and then remove the shield, as shown in Figure 2-3.

b. Refer to Figure 2-4. Loosen and remove the printed circuit board mounting screws, as shown in the figure.

c. Remove the printed circuit board assembly by lifting it up and out of the 3468A/B's bottom assembly. Set the bottom assembly aside.

d. Refer to Figure 2-5 and locate the power line jumper.

e. Obtain a low wattage (25W) soldering iron. Unsolder and remove the power line jumper from the printed circuit board.

f. Refer to Figure 2-5 to determine into which position the power line jumper is to be placed. Then install the jumper into the holes which select the desired power line voltage. (The solder in the holes may have to be removed before the jumper can be installed.) Make sure there is a good solder joint between the jumper and printed circuit board trace. The line voltages and corresponding jumper locations are as follows:

Jumper	Line Voltage
100V	90V to 105V
120V	106V to 126V
220V	198V to 231V
240V	216V to 252V

g. Once the jumper has been installed into the correct position, place the printed circuit board into the bottom assembly.

h. Reinstall the printed circuit board mounting screws. Then reinstall the inner shield and the shield mounting screw. Continue with paragraph 2-11 to reassemble the instrument.

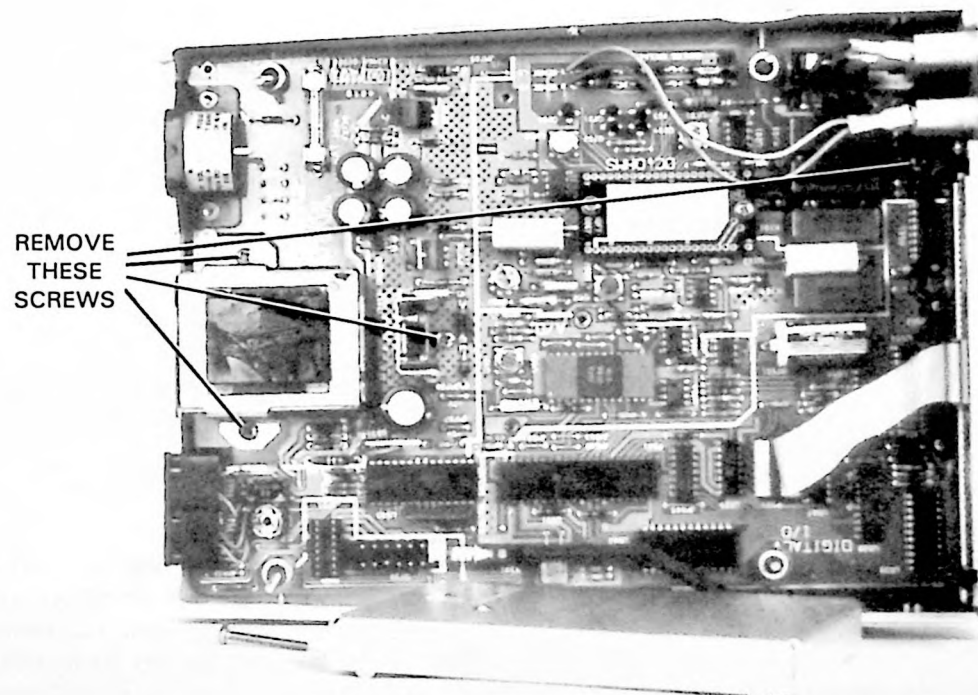


Figure 2-4. Top View with Inner Shield Removed (Model 3468A shown)



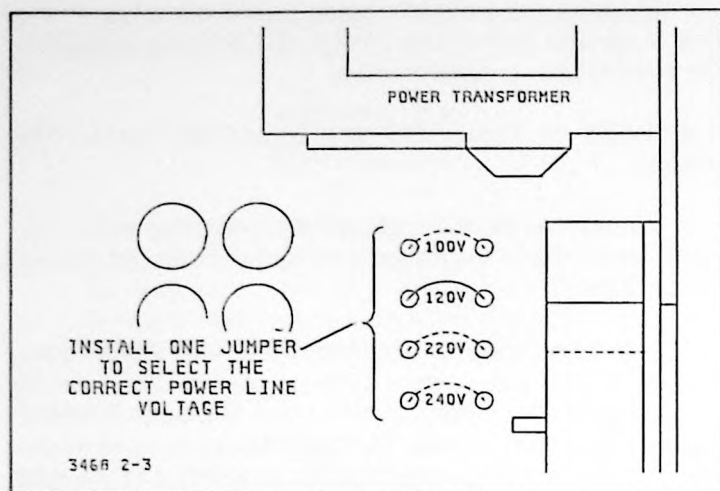


Figure 2-5. Power Line Voltage Configuration

## 2-11. 3468A/B Reassembly. Do the following:

a. If the optional battery circuitry (Option 001) is NOT installed, continue with step b. If the battery circuitry is installed, do the following:

1. Obtain the top cover assembly (which was previously removed in paragraph 2-9) and set it next to the bottom assembly, as shown in Figure 2-3.
2. Locate the red stripe on the cable from the battery circuitry. Then plug the cable into the battery charger socket (J701) with the red stripe facing away from the bottom assembly. It is important that the battery cable is plugged in correctly, or the battery can be discharged and the power fuse may blow.

### CAUTION

*Make sure the cable between the battery circuitry and main printed circuit board is in the correct position, or the battery can be discharged and the power fuse may open.*

b. Reinstall the top cover assembly on the bottom assembly insuring that the display, handle (3468A only), and spacers fit properly into their respective locations. Also make sure the battery cable does not interfere with a spacer. Then tighten the four screws at the bottom of the instrument. If the instrument is a 3468B, make sure the two rear feet are reinstalled.

c. If the power line voltage and/or line frequency switch (on the rear panel) was changed, update the rear panel of the instrument to show the new changes.

### NOTE

*Refer to paragraph 7-13 (Section VII) of this manual for information on how to replace the front panel Amps fuse and the power fuse.*

## 2-12. POWER CORDS AND RECEPTACLES

2-13. Figure 2-6 illustrates the different power plug configurations that are available to provide power to the 3468A/B. The -hp- part number shown directly below the individual power plug drawing is the part number for the power cord set equipped with the appropriate mating plug for that receptacle. If the appropriate power cord is not included with the instrument, notify the nearest -hp- Sales/Service office and a replacement will be provided.

## 2-14. HP-IL INTERFACE CONNECTIONS

2-15. The 3468A/B is compatible with the Hewlett-Packard Interface Loop. The interface connection is made by a pair of two-wire balanced line cables. The cable is limited to 10 meters (32.8 feet) for unshielded cables (from one device to the next) and to 100 meters (328 feet) for shielded cables. A typical interface connection is in Figure 2-7.

## 2-16. ENVIRONMENTAL REQUIREMENTS

### WARNING

*To prevent electrical fire or shock hazards, do not expose the instrument to rain or excessive moisture.*

## 2-17. Operating and Storage Temperature

2-18. To meet and maintain the specifications listed in Table 1-1, the 3468A/B should be operated within  $\pm 5^{\circ}\text{C}$  ( $\pm 9^{\circ}\text{F}$ ) of the Reference Temperature. The Reference temperature is the temperature in which the 3468A/B was last calibrated. For example, if the last Reference Temperature was  $23^{\circ}\text{C}$  ( $73^{\circ}\text{F}$ ), the 3468A/B should maintain its specifications if operated within  $\pm 5^{\circ}\text{C}$  ( $\pm 9^{\circ}\text{F}$ ) of that temperature. The factory temperature is from  $18^{\circ}\text{C}$  to  $28^{\circ}\text{C}$  ( $64^{\circ}\text{F}$  to  $82^{\circ}\text{F}$ ). The 3468A/B may be operated within an ambient temperature range of  $0^{\circ}\text{C}$  to  $55^{\circ}\text{C}$  ( $32^{\circ}\text{F}$  to  $131^{\circ}\text{F}$ ) with less accuracy.

## 2-19. REPACKAGING FOR SHIPMENT

### NOTE

*If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair made. Include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number and full serial number. If you have any questions, contact your nearest -hp- Sales/Service office.*

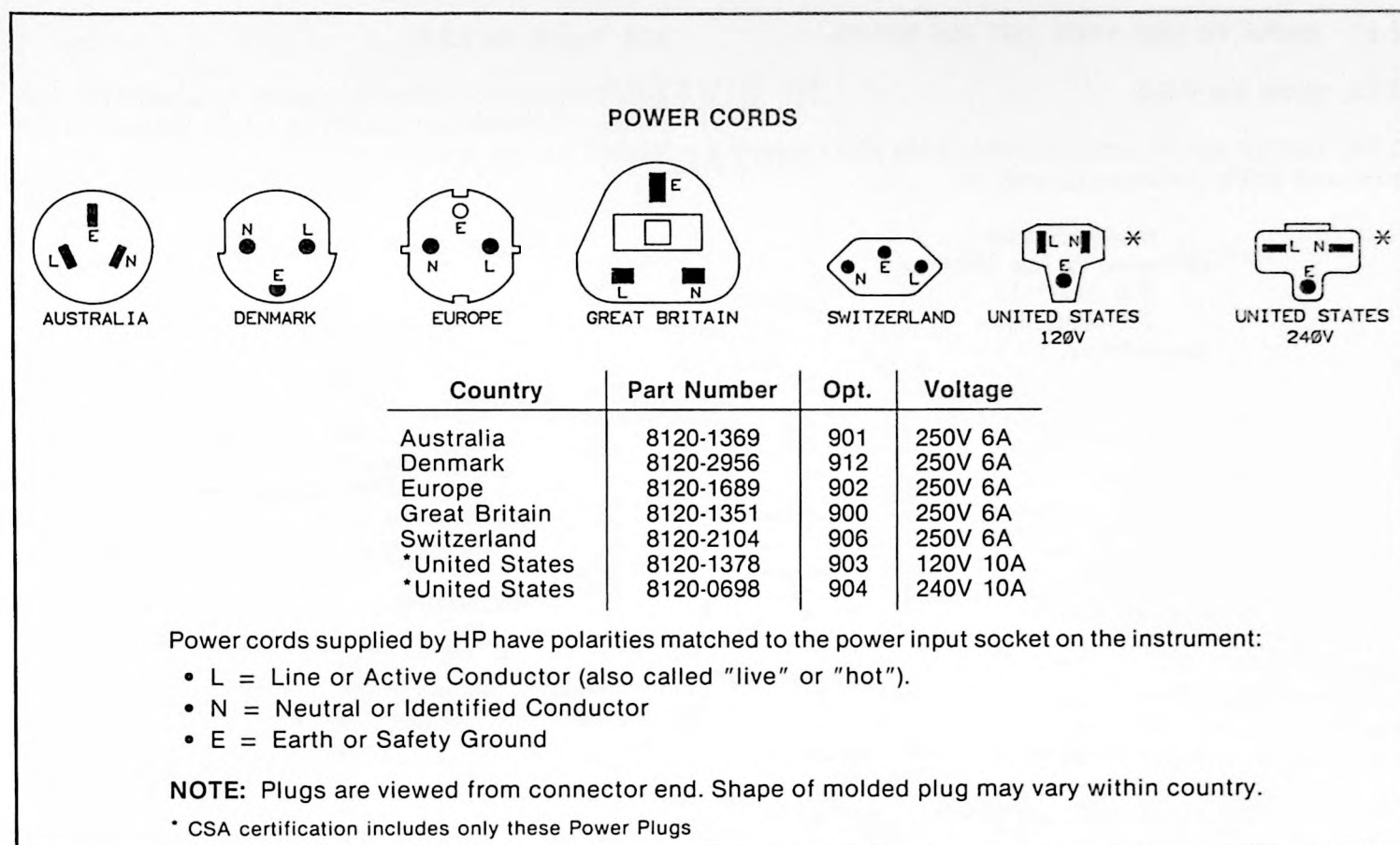


Figure 2-6. Power Cables

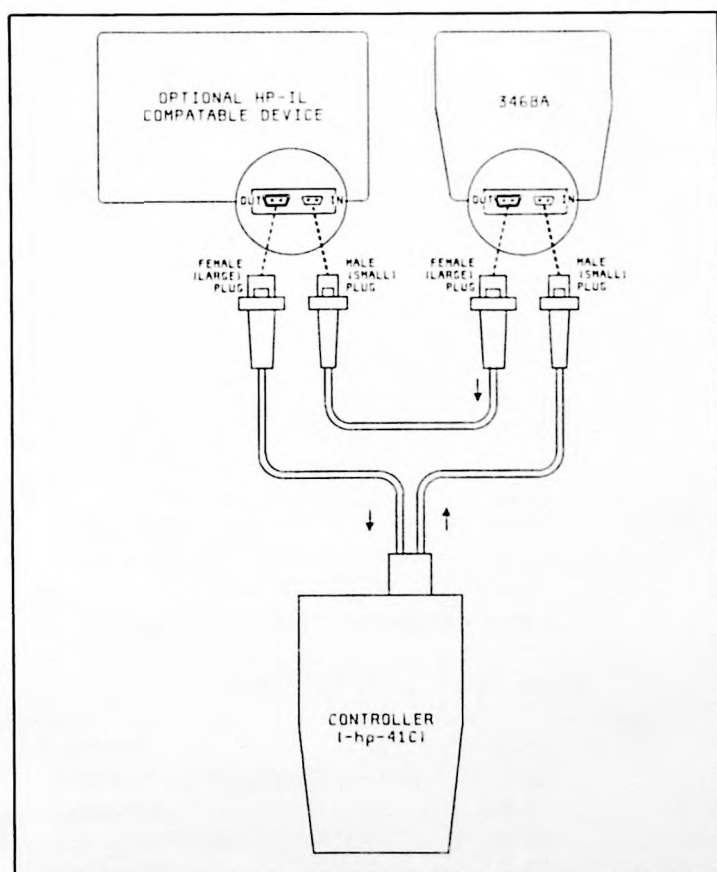


Figure 2-7. Typical HP-IL Interface Connection

2-20. Place the instrument in its original container with appropriate packaging material and secure with strong tape or metal bands. If the original container is not available, a replacement can be purchased from your nearest -hp- Sales/Service office. Hewlett-Packard suggests that you always insure shipments.

2-21. If the original container is not to be used, do the following:

- Wrap the instrument in heavy plastic, before placing in an inner container.
- Place packing material around all sides of the instrument and protect the front panel with cardboard strips.
- Place the instrument in the inner container in a heavy carton. Seal the carton with strong tape or metal bands.
- Mark shipping container "DELICATE INSTRUMENT", "FRAGILE", etc.



**2-22. WHERE TO SHIP YOUR UNIT FOR REPAIR**

**2-23. Inside the U.S.A.**

2-24. For fast service, return the unit along with the service card safely packaged directly to:

**Hewlett-Packard  
Instrument Service Center  
P.O. Box 7922  
690 Middlefield  
Mountainview, CA 94042**

**2-25. Outside the U.S.A.**

2-26. Return your unit to the nearest designated Hewlett-Packard Sales and Service Office. Check the back of this manual for the address.

## SECTION III OPERATION

### 3-1. INTRODUCTION

3-2. This section of the manual has the information and instructions for the operation of the 3468A/B Multimeter, showing front panel and remote operation. The information is an abbreviated description of the operation and is written for a Service Trained Person, rather than an Operator. For more complete operating instructions, refer to the 3468A/B's Operators Manual. To familiarize yourself with the front and rear panel features or for a review of instrument operations, refer to Figure 3-1.

3-3. The Operation Section is separated into the following major areas: General Information, Front Panel Operation, Shifted Operation, and Remote Operation (HP-IL). It is suggested that you read the Remote Operation Chapters last, since you need to know the other operations to understand the remote operation. The major areas are as follows:

- a. General Information - paragraph 3-4.

Title	Paragraph
AC Power Operation	3-5
Battery Operation	3-7
Turn-On	3-9
Display	3-12
Input Terminals	3-14
Miscellaneous	3-16

- b. Front Panel Operation - paragraph 3-19

Title	Paragraph
DC Volts Measurement	3-20
AC Volts Measurement	3-24
Resistance Measurement	3-28
DC Current Measurement	3-32
AC Current Measurement	3-36
Ranging	3-40
Triggering	3-45

- c. Shifted Operation - paragraph 3-49

Title	Paragraph
General	3-50
Number Of Digits Displayed	3-53
Autozero	3-56
Self-Test/Reset Operation	3-59
Calibration	3-62

- d. Remote Operation - paragraph 3-65.

Title	Paragraph
General	3-66
3468A/B Response To Loop Messages	3-70
3468A/B Addressing	3-91
Talk-Only Mode (No Controller)	3-94
3468A/B HP-IL Programming	3-96
Advanced Programming	3-108

### 3-4. GENERAL INFORMATION

#### 3-5. AC Power Operation

3-6. Before connecting ac power to the 3468A/B, make sure the power source matches the power requirement of the multimeter (as marked on the option label at the rear panel). If the instrument is incompatible with the power source, refer to Section II of this manual for power requirement modification.

#### 3-7. Battery Operation (Option 001)

3-8. Make sure the 3468A/B's battery is charged before operating the multimeter in the battery mode. The maximum charge current is approximately 400mA and is generated when the 3468A/B is plugged in and its power switch off. The current is approximately 130mA when the power switch is on. The multimeter will not operate if the battery voltage is below approximately 5.5V (nominal voltage is 6V). Battery voltage can be checked by first pressing  $\equiv V$  button and then, with a probe connected to the HI INPUT terminal, touch the battery voltage check pad through the access hole in the bottom cover.

#### 3-9. Turn-On

3-10. When the 3468A/B is first turned on, the multimeter goes through an Internal Test routine. During the test, all the display segments are lit. When the test is completed and the 3468A/B passes the test, "SELF TEST OK" will be displayed for about one second. If the Self-Test fails, refer to Section VII of this manual for troubleshooting information. For more information on the Self-Test, refer to paragraph 3-59.

3-11. Once the Self-Test is completed, the 3468A/B goes to its turn-on state which is:

```

FUNCTION.....DCV
RANGE.....AUTO
TRIGGER.....INTERNAL
AUTOZERO.....ON
NUMBER OF DIGITS DISPLAYED....5
  
```



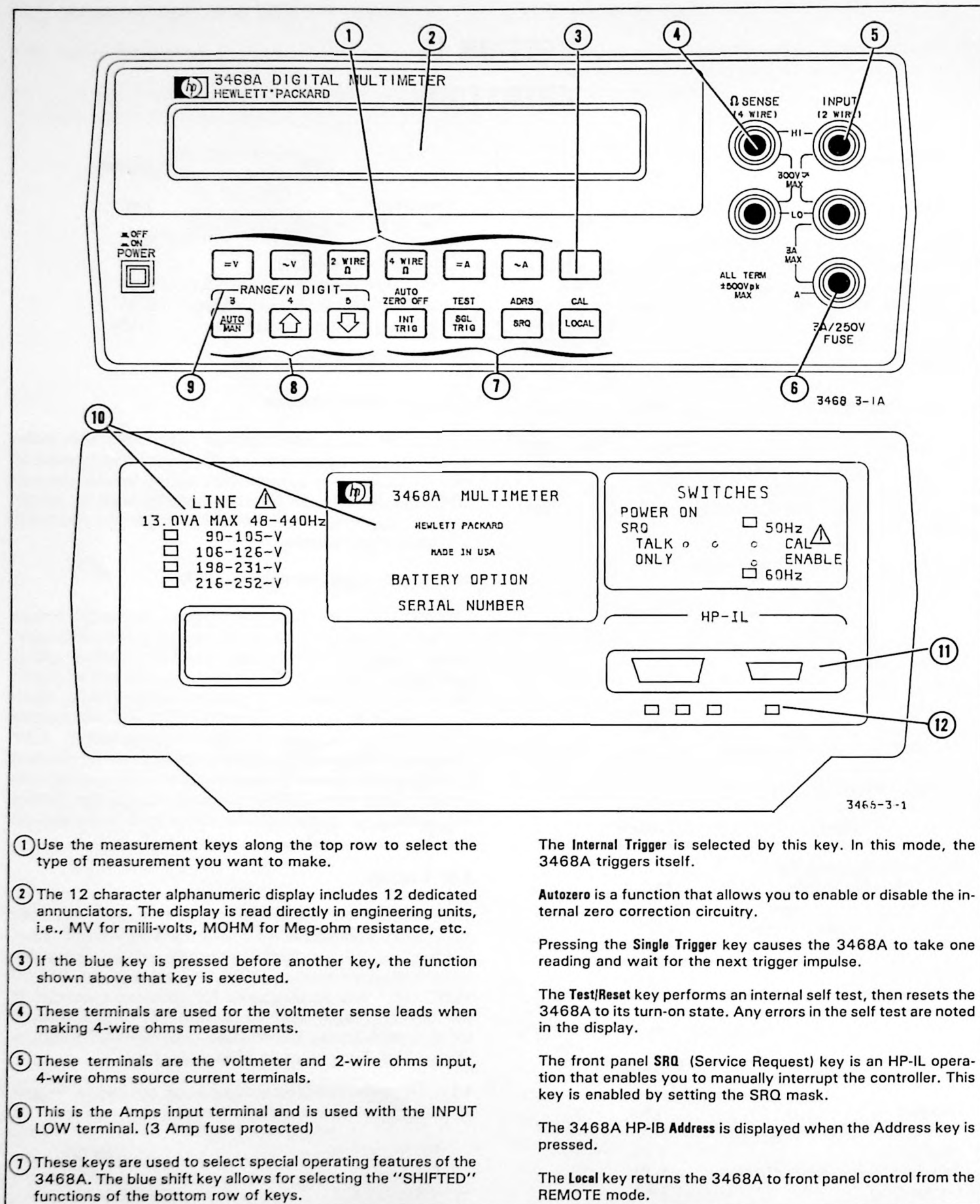


Figure 3-1. 3468A/B Front and Rear Panel Features

The 3468A features total electronic calibration. The Cal key is used as part of that procedure. See Section IV.

- ⑧ The range keys are used to select the proper range for the measurement. Press any of the keys to select the manual range mode. Note the M RNG annunciator in the display. The Auto/Man key will return the meter to autorange.

- ⑨ The "SHIFTED" functions of the range keys are used to select alternate numbers of display digits.

- ⑩ The Option Label shows the instrument's power option.

- ⑪ HP-IL Connector.

- ⑫ These switches select the Talk-Only mode, Power-On SRQ feature, correct power line frequency (50Hz or 60Hz), and Cal Enable, left to right respectively.

Figure 3-1. Front and Rear Panel Features (cont'd)

### 3-12. Display

3-13. The Display is a 12 character alphanumeric Liquid Crystal Display (LCD) with 12 annunciators. The display is normally used to show readings, however, the display can also show alphanumeric messages (sent remotely). The four characters to the right show the function and the 8 characters to the left show the reading (e.g. +.123657 DCV). If a reading is not available (due to a remote programming error), "INVALID" will be displayed. An "OVLD" is displayed if the input is out of range for the selected range and function.

### 3-14. Input Terminals

3-15. The 3468A/B has five Input Terminals which are: INPUT HI, INPUT LO,  $\Omega$  SENSE HI,  $\Omega$  SENSE LO, and A (Amps) terminal. The INPUT HI and LO Terminals are used for measuring dc volts, ac volts, and resistance in the 2-Wire Ohms configuration. Refer to Figure 3-2 for a typical connection. The  $\Omega$  SENSE HI and LO Terminals (in conjunction with the INPUT Terminals) are used in the 4-Wire Ohms configuration. Refer to Figure 3-4 for a typical ohms connection. The A (Amps) Terminal with the INPUT LO Terminal is used to measure ac or dc current. Refer to Figure 3-3 for a typical current connection.

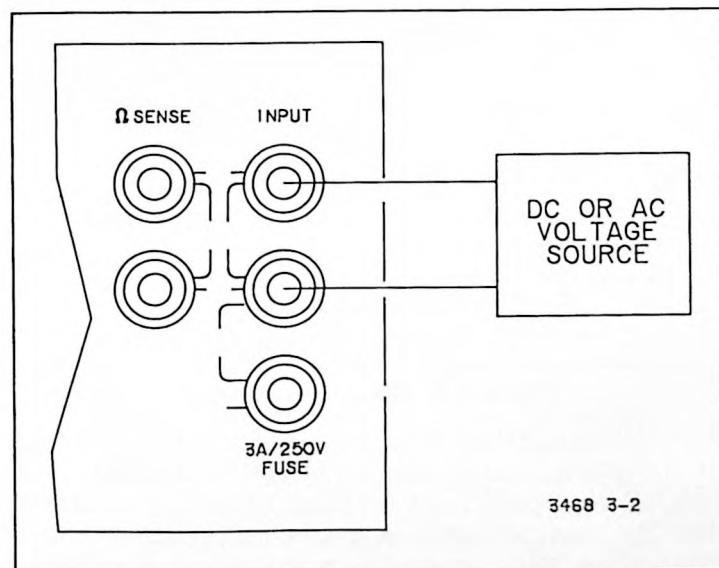


Figure 3-2. Typical Input Measurement Connection

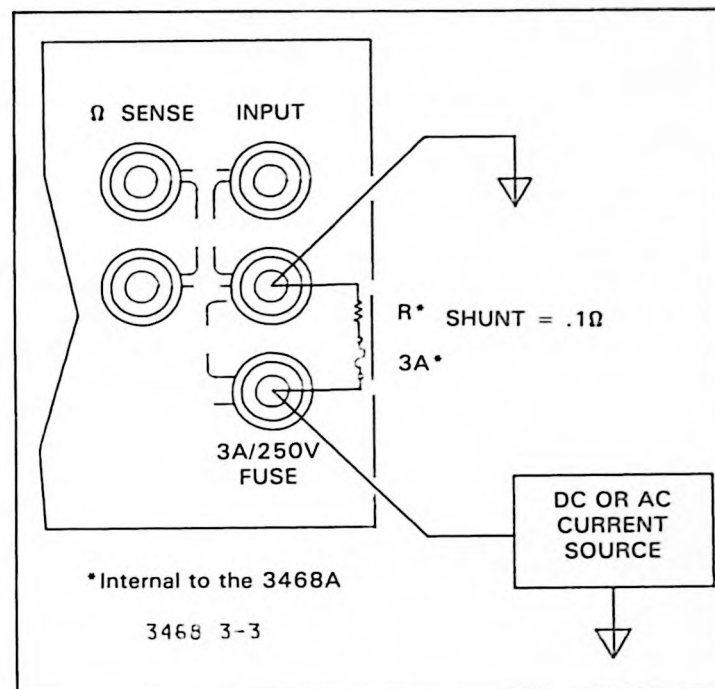


Figure 3-3. Typical Current Measurement Connection

### 3-16. Miscellaneous

3-17. **Option Label.** The 3468A/B has an option label on the rear panel to show the power source to which the instrument is configured. Whenever the 3468A/B is re-configured, the option label should be changed to show the new power configuration (see Section II of this manual).

3-18. **Information Decal.** An information decal showing the capabilities of the 3468A/B is affixed to the underside of the multimeter. The decal can be used as a quick reference guide for the 3468A/B.

### 3-19. FRONT PANEL OPERATION

#### 3-20. DC Volts Measurements

3-21. The 3468A/B is able to make dc volts measurements from 1uV to 300V in four ranges: .3V, 3V, 30V, and 300V. All ranges are protected from input voltages up to 450V peak. Select the DC Volts Function for dc volts measurements by pressing the  $\text{---}V$  button.



3-22. In the DC Volts Function, ranging is done in the Input Circuitry of the 3468A/B. The result is that the input to the A/D Converter (which changes the voltage to digital information) has the same value in all ranges for all full scale inputs (e.g. 10V input to the A/D for .3V, 3V, etc. inputs to the 3468A/B).

3-23. When the DC Volts Function is selected, the right side of the display shows "VDC" to indicate that the function is selected. The resultant reading can be displayed either as a 5 1/2, 4 1/2, or 3 1/2 digit reading, dependent on the selected Number Of Digits Displayed (see paragraph 3-53). Refer to Table 1-1 or Table 4-1 for the DC Volts Function's accuracy specifications.

### 3-24. AC Volts Measurements

3-25. The 3468A/B uses a True RMS AC to DC Converter to measure ac voltages from .03V to 300V in four ranges: .3V, 3V, 30V, and 300V. The response of the converter is from 20Hz to 100KHz on all ranges (to 300KHz on the 30V Range only). All ranges are protected from input voltages up to 450V peak. Select the AC Volts Function for ac volts measurements by pressing the ~V button.

3-26. The AC to DC Converter changes the ac input voltage to dc volts, which is then measured by the 3468A/B's A/D Converter. All ranging is done in the AC to DC Converter, applying the same voltage value to the A/D Converter for all full scale inputs.

3-27. When the AC Volts Function is selected, the right side of the display shows "VAC" to indicate that the function is selected. The resultant reading can be displayed either as a 5 1/2, 4 1/2, or 3 1/2 digit reading, dependent on the selected Number Of Digits Displayed (see paragraph 3-53). A .6 second delay is also applied in the AC Volts Function before a reading is taken (also, during a range change). Refer to Table 1-1 or Table 4-1 for the AC Volts Function's accuracy specifications.

### 3-28. Resistance Measurements

3-29. The 3468A/B is able to make resistance measurements from .001 ohms to 30M ohms in six ranges. The ranges extend from the 300 ohm to the 30M ohm range. All ranges are protected from input voltages up to 350V peak. Resistance measurements can be made using either the 2-Wire or 4-Wire ohms configuration, which are selected by the 2 WIRE  $\Omega$  and 4 WIRE  $\Omega$  buttons, respectively. Refer to Figure 3-4 for the correct ohms connections.

3-30. Resistance measurements are made by applying a known current (generated by the 3468A/B) to the unknown resistance. The resultant voltage drop is then measured by the 3468A/B's dc circuitry (Input Circuitry and A/D Converter). In the 2-Wire Ohms Function, the voltage drop is measured across the HI and LO INPUT

Terminals. In the 4-Wire Ohms Function, the voltage is measured across the HI and LO  $\Omega$  SENSE Terminals. The Ohms Current Source generates the known current which is applied to the unknown resistance (in both ohms functions) from the HI INPUT Terminal. The current values are as follows:

Range	Current
300 ohm	1mA
3K ohm	1mA
30K ohm	100uA
300K ohm	10uA
3M ohm	1uA
30M ohm	.1uA

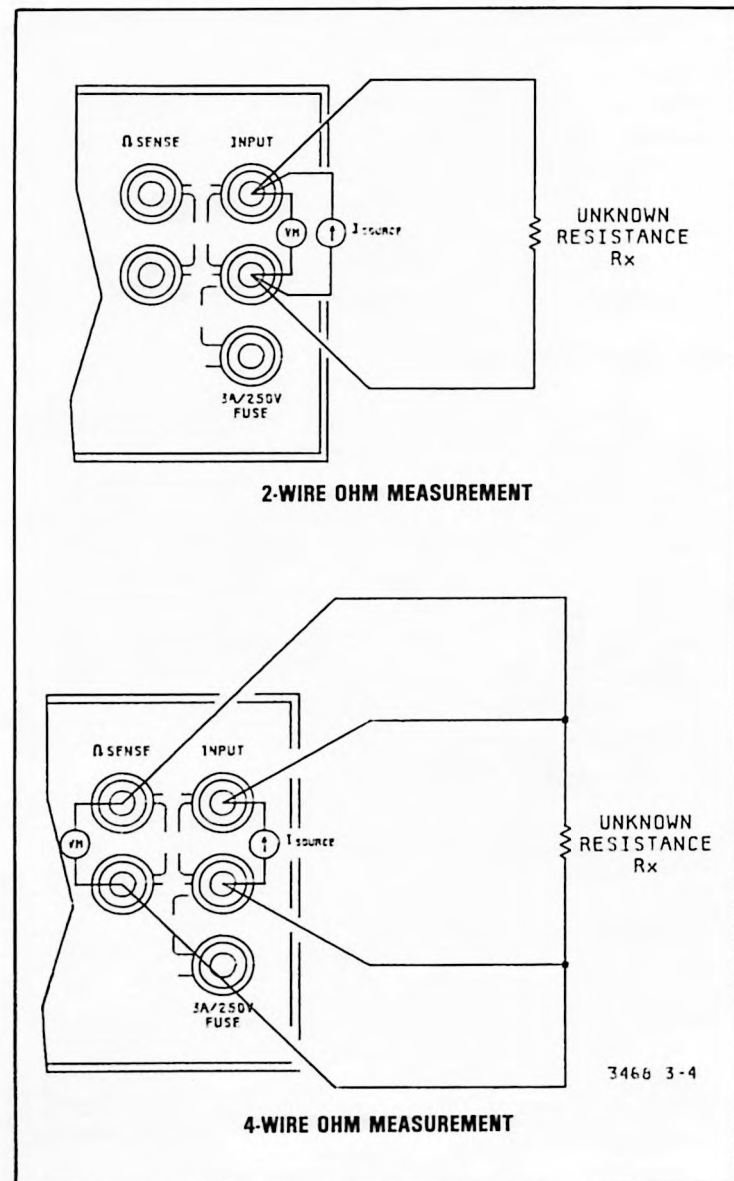


Figure 3-4. Ohms Connections

3-31. When an Ohms Function is selected, the right side of the display shows either "OHM", "KOHM", or "MOHM", dependent on the range selected. In addition, the "2 $\Omega$ " annunciator is on for the 2-Wire Ohms Function and the "4 $\Omega$ " annunciator is on for the 4-Wire Ohms Function. The ohms reading can be displayed either as

a 5 1/2, 4 1/2, or 3 1/2 digit reading, dependent on the selected Number Of Digits Displayed (see Paragraph 3-53). A .02 second or a .2 second delay is also applied before each reading in the 3M ohm and 30M ohm Range, respectively. Refer to Table 1-1 or Table 4-1 for the Ohms Function's accuracy specifications.

#### NOTE

*The 3468A/B will show a negative resistance if small negative voltages exist on the circuit under test, or the Ohms Sense and Input Leads are reversed from each other. This only happens in the 4-Wire Ohms Function.*

### 3-32. DC Current Measurements

3-33. The 3468A/B can make dc current measurements from 10 $\mu$ A to 3A in one range: 3A. The range is protected from excessive currents and voltage by a 3A 250V fuse. Select the DC Current Function to measure dc currents by pressing the  $\Rightarrow$ A button.

3-34. In the DC Current Function, the current is applied between the INPUT LO and A Terminals. Since a known value resistor (.1 ohm) is connected between the terminals, a voltage proportional to the unknown current and the resistor is generated. This voltage is measured by the 3468A/B's dc circuitry (Input Circuitry and A/D Converter).

3-35. When the DC Current Function is selected, the right side of the display shows "ADC" showing the function selected. The readings can be displayed either as a 5 1/2, 4 1/2, or 3 1/2 digit reading, depending on the selected Number Of Digits Displayed (see paragraph 3-53). Refer to Table 1-1 or Table 4-1 for the DC Current Function's accuracy specifications.

#### CAUTION

*The current function is protected by a fuse of 250 V rating. To avoid damage to the Multimeter, current sources having open circuit voltages greater than 250 V (dc + peak ac) must not be connected to the A (amps) input terminal.*

#### NOTE

*Current inputs of greater than 1 amp may cause internal heating of the multimeter which, if sustained for more than 30 seconds, may cause inaccuracies. Allow sufficient time for the circuitry to settle after measurement is complete and before other critical measurements are made.*

### 3-36. AC Current Measurements

3-37. The 3468A/B can make ac current measurements from 30mA to 3A in two ranges: 300mA and 3A. The frequency response is from 20Hz to 20KHz. The ranges are protected from excessive currents and voltage by a 3A 250V fuse. Select the AC Current Function to measure ac currents by pressing the  $\sim$ A button.

3-38. The AC Current Function is similar to the DC Current Function (see paragraph 3-32); a voltage drop across a resistor is measured. The difference is that the resultant ac voltage is changed from ac to dc using the AC to DC Converter. Similar to the AC Volts Function, all ranging is done in the converter.

3-39. When the AC Current Function is selected, the right side of the display shows "AAC", showing the function selected. The readings can be displayed either as a 5 1/2, 4 1/2, or 3 1/2 digit reading, dependent on the selected Number Of Digits Displayed (see paragraph 3-53). Refer to Table 1-1 or Table 4-1 for the AC Current Function's accuracy specifications.

### 3-40. Ranging

3-41. The 3468A/B has two range modes: Manual and Autorange. Manual ranging is selected by pressing the AUTO/MAN button (if the 3468A/B is in Autorange) or by pressing either the  $\uparrow$  or  $\downarrow$  buttons. The "MRNG" annunciator on the display then turns on. The following explains the different range modes.

3-42. **Uprange.** The 3468A/B upranges to the next higher range each time the  $\uparrow$  button is pressed. The highest selectable range depends on the function selected (e.g. 300V for the AC Volts and DC Volts Functions). If a function is selected with its highest range lower than the previous range, the multimeter defaults to the new highest range.

3-43. **Downrange.** The 3468A/B downranges to the next lower range each time the  $\downarrow$  button is pressed. The lowest selectable range depends on the function selected (e.g. .3V for the DC Volts Function). If a function is selected with its lowest range higher than the previous function, the multimeter defaults to the new lowest range.

3-44. **Autorange.** The 3468A/B selects the optimum range when this mode is selected. The mode is selected when the 3468A/B is first turned on or by pressing the AUTO/MAN button (if in Manual Range). When Autorange is enabled, the 3468A/B upranges when the reading is at or above  $\pm 30100$  and downranges at or below  $\pm 027000$ . The numeric range points are irrespective of decimal placement. Refer to Figure 3-5 for the autorange points (the example is for the DC Volts Function; other functions are similar).



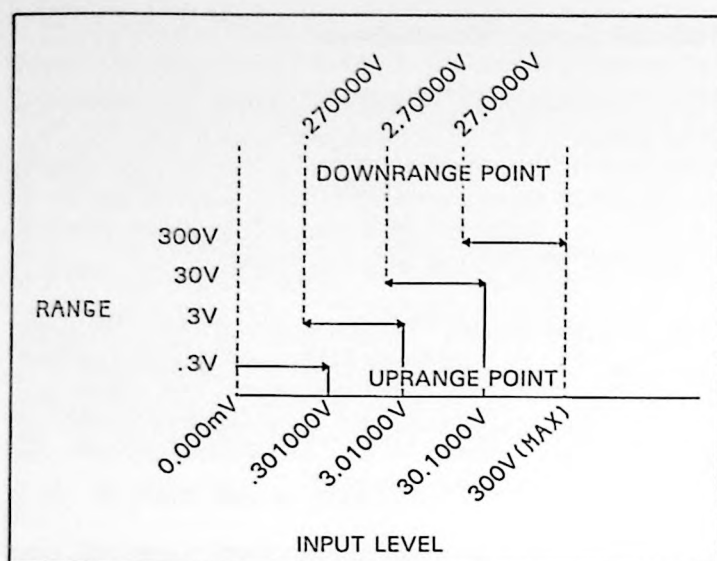


Figure 3-5. Autoranging Points

### 3-45. Triggering

3-46. The 3468A/B has two trigger modes: Internal and Single. The following paragraphs explain the trigger modes.

3-47. **Internal Trigger.** In this mode, the measurement cycle is internally initiated and the 3468A/B makes the measurements at the maximum reading rate. The Internal Trigger is selected at instrument turn on or by pressing the INT/TRIG button.

3-48. **Single Trigger.** In this mode, a measurement cycle is initiated each time the SGL/TRIG button is pressed. When the button is initially depressed, the 3468A/B initiates a measurement cycle and then places the multimeter in the Single Trigger mode. The "S TRG" annunciator on the display also turns on, when the SGL/TRG button is pressed. If the button is pressed during a measurement cycle (while in the Single Trigger mode), the 3468A/B starts a new measurement cycle. When the cycle is completed, a new cycle can then be initiated by pressing the button.

#### NOTE

*When the 3468A/B is in the Single Trigger mode and an attempt is made to change range or function, the left portion of the display goes blank (except for the decimal point) until another reading is taken (instrument triggered).*

### 3-49. SHIFTED OPERATION

#### 3-50. General

3-51. The Shifted Operation of the 3468A/B is used to expand the capabilities of the multimeter using the same number of front panel pushbuttons. This is done by us-

ing the bottom row of front panel buttons for two different operations, shifted and unshifted. An unshifted operation (AUTO/MAN, INT/TRIG, etc.) is normally selected by pressing a single button. A shifted operation is done by first pressing the blue "SHIFT" button (on the right end of the upper row of buttons) and then pressing one button (on the lower row). To select a new shifted operation, press the blue button again and the button for the new operation. Table 3-1 lists the shifted operations and corresponding buttons. The shifted operations are also shown in blue lettering above the buttons.

3-52. When the blue Shift button is pressed, the "SHIFT" annunciator on the display is on. The annunciator remains on until a different button is pressed.

Table 3-1. Shifted Operations

Shifted Operation	Select Button	Description of Operation
3 Digit (Disp)	AUTO/MAN	Selects 3 Digits Displayed (see paragraph 3-53).
4 Digit (Disp)	↕	Selects 4 Digits Displayed (see paragraph 3-53).
5 Digit (Disp)	↕	Selects 5 Digits Displayed (see paragraph 3-53).
AUTOZERO	INT/TRIG	Turns Autozero on or off (see paragraph 3-56).
TEST/RESET	SGL/TRIG	Places the 3468A/B into its Internal Test Mode (see paragraph 3-59).
ADRS	SRQ	Displays the 3468A/B's current HP-IL Address. Code (see Paragraph 3-92).
CAL	LOCAL	Places the 3468A/B into the calibration mode

### 3-53. Number Of Digits Displayed

3-54. The 3468A/B can display readings in either 5 1/2, 4 1/2, or 3 1/2 digits. The 5 1/2, 4 1/2, and 3 1/2 digits can be selected by first pressing the blue Shift button and then either the AUTO/MAN, ↕, or ↕ button, respectively.

3-55. The Number Of Digits Displayed affects the reading rate of the multimeter. This is because the number of digits determines the integration time of the A/D Converter. In the 4 1/2 digit mode, the integration time is 1/60 second (or 1/50 second for the 50Hz option), which is called 1 PLC (Power Line Cycle). In the 3 1/2 digit mode, the time is 1/600 second (for both 60Hz and 50Hz options), which is .1 PLC. In the 5 1/2 digit mode, the 3468A/B takes 10 readings using the 4 1/2 digit mode and averages them together for an extra digit of resolution. This takes a time of 1/6 second (or 1/5 second in the 50 Hz option) which is 10 PLC. For more information on the integration time and the A/D Converter, refer to this manual's Section VII (chapter on the A/D Converter theory of operation).

### 3-56. Autozero

3-57. The Autozero Function of the 3468A/B is used to compensate for offsets that may be present in the multimeter's internal circuitry (DC/Ohms Input Amplifier, A/D Converter, etc.). The method used is to temporarily connect the input of the input amplifier to ground (INPUT LO Terminal) and take a measurement (the INPUT HI Terminal is open at this time). The offset reading is then stored into the 3468A/B's internal memory. After that, the short is removed and a regular input measurement is made. The offset reading is then subtracted from the input reading and the compensated reading is displayed.

3-58. The Autozero feature is enabled when the 3468A/B is turned on and after doing a Self-Test (see Paragraph 3-59). The feature can be disabled by pressing the blue Shift button and then the INT/TRIG button. The "AZ OFF" annunciator on the display will light, showing that the function is off. After the function is turned off, the multimeter immediately takes an offset reading and stores it into memory. This last reading is then subtracted from the input measurements that follow. Since no more offset readings are taken, the reading rate of the 3468A/B is faster (up to twice as fast). If a range, function, or digit change is made, or an attempt is made to calibrate the 3468A/B, a new offset reading is taken. With Autozero off, the 3468A/B's input circuitry remains in a static state. This is useful when making measurements in extremely high impedance circuits where the internal switching transients of the 3468A/B may affect the reading accuracy.

#### NOTE

*The 3468A/B's long term stability may be affected, if the Autozero feature is disabled.*

### 3-59. Self-Test/Reset Operation

3-60. The 3468A/B uses an Internal Self-Test to check its display and internal circuitry. The multimeter goes through the test at turn-on and also by pressing the blue Shift button and then the SGL/TRG (TEST/RESET) button. When the test is selected, all the segments of the display (except the upper dots of the colons) are on for about five seconds. After the Self-Test is completed, the display indicates "SELF TEST OK" (if the test passes) for about one second. The 3468A/B then goes back to its turn-on state (see paragraph 3-9), not the previous state. If you wish to view the message longer than normally displayed, hold the SGL/TRG (TEST/RESET) button down and the message remains on the display. After the button is released, the 3468A/B then goes to its turn-on state.

3-61. If the Self-Test fails, an error message will be displayed for about one second. The message is "ERROR dd", where dd is the summation of the in-

dividual error numbers (an error number pertains to a test failure). This message can also be viewed longer than normally by holding the SGL/TRG (TEST/RESET) button down. The error numbers and corresponding failures are as follows:

Error Number	3468A/B Failure
1	Calibration RAM Error
2	RAM Error
4	ROM Error
8	A/D Converter Error

### 3-62. Calibration

3-63. The 3468A/B does not have any adjustments to calibrate the instrument; calibration is done electronically. A known good calibration source is applied to the instrument and the value of the known source is entered into the instrument. A reading is then taken and compared with the entered value. A Calibration Constant is calculated (from the entered value) to correct the reading to the known value, and then stored into the instrument's memory. The correct readings are then calculated using the constants and then displayed.

3-64. When calibrating the 3468A/B, first the rear panel switch number 8 has to be set to CAL ENABLE (down). Then the calibration process becomes a simple four step procedure: configure the instrument to the desired function and range, apply a known source, set the display, and start the calibration cycle. These steps can be performed either from the front panel or remotely. Refer to Section IV for further calibration procedures.

#### NOTE

*The CAL ENABLE Switch on the rear panel should not be in the CAL/ENABLE position under normal use. It should only be in that position to calibrate the instrument.*

### 3-65. REMOTE OPERATION

#### 3-66. General

3-67. The following paragraphs give device dependent information necessary to remotely operate the 3468A/B over the Hewlett-Packard Interface Loop (HP-IL). Directions for mechanical interface connections to the HP-IL are given in Section II of this manual. Familiarize yourself with the front panel operation (local) before attempting to use the multimeter in remote (HP-IL).

3-68. The Hewlett-Packard Interface Loop is a two wire, serial interface that permits communication from one device to another. A general description of the HP-IL is in this manual's Appendix A. Refer to the appendix for any non-3468A/B related HP-IL information.



3-69. The following lists the different 3468A/B remote operations. Note that not all controllers will be capable of executing all Loop messages. Refer to the Operators Manual for more information on programming the 3468A/B. The Operators Manual covers programming the 3468A/B with BASIC language controllers such as the -hp-Model 85 as well as RPN language controllers such as the -hp-Model 41C/CV. This section assumes that the reader has a general understanding of programming.

a. 3468A/B Response to Bus Messages (paragraph 3-70).

Title	Paragraph
Data	3-72
Trigger (GET)	3-73
Clear (DCL or SDC)	3-74
Remote	3-75
Local	3-76
Local Lockout	3-77
Clear Lockout and Set Local	3-78
Require Service (SRQ)	3-79
Status Byte	3-81
Programming the SRQ Mask	3-86
Status Bit	3-88
Pass Control	3-89
Abort	3-90

b. 3468A/B Addressing (paragraph 3-91) and Talk-Only Mode (paragraph 3-94).

c. 3468A/B HP-IL Programming (paragraph 3-96).

Title	Paragraph
General	3-97
Program Codes	3-99
Power-On SRQ	3-101
Sending Data to the Display	3-102
Reading Data from the 3468A/B	3-104
Data Ready Feature	3-106
Front Panel SRQ	3-107

d. Advanced Programming (paragraph 3-108).

Title	Paragraph
General	3-109
Extended Ohms Operation	3-110
Reading the Binary Status Byte	3-111

### 3-70. 3468A/B Response to Loop Messages

3-71. The following paragraphs explain the 3468A/B's response to Loop Messages. The multimeter's Loop capabilities are in Table 3-2.

Table 3-2. 3468A/B's Loop Capabilities

Mnemonic	Interface Function Name
R	The 3468A/B handshakes as a receiver
D	Handshakes as a driver to the next device
AH	Handshakes as an acceptor
SH1	Handshakes as a source
T1,2,3,5,6	Basic Talker, Send Status, Send Device ID, Talk Only and unaddressed as a Talker when addressed to Listen
TE0	No extended talker capability
L1,3	Basic Listener and unaddressed to listen when addressed to Talk
LE0	No extended Listener capability
C0	The 3468A/B cannot serve as a controller
AA1	Can be autoaddressed by the controller
AE0	No extended addressing capability
AM0	No multiple addressing capability
DC2	The 3468A/B responds to Device Clear and Selected Device Clear
DT1	The 3468A/B responds to Device Trigger
RL2	Basic Remote, Local, and Local Lockout capability
SR2	Basic Service Request and Asynchronous Service Request capability
PP0	No Parallel Poll capability
MS1	The 3468A/B does have Manual Service Request capability
PDO	No power-down capability
DDO	The 3468A/B does not implement Device Dependent Talker or Listener commands

3-72. **Data.** The Data Message is used to transfer information between the 3468A/B and the controller.

a. The message is used to send data to the multimeter and consists primarily of set-up information (e.g. DCV, 30V Range, etc.). The 3468A/B is the Listener and the controller is the Talker.

b. The message is also used by the controller to receive data from the 3468A/B. This includes the multimeter's output (readings) and status information. In this case, the 3468A/B is the Talker and the controller is the Listener.

3-73. **Trigger (GET, Group Execute Trigger).** The Trigger message causes the 3468A/B to initiate a measurement cycle. It is an HP-IL Trigger and triggers the multimeter in either trigger mode, since it has priority over the other trigger modes. If the 3468A/B is triggered during a measurement cycle, the cycle is aborted and a new cycle is initiated. The multimeter has to be programmed to "listen" to execute the trigger.

3-74. **Clear (DCL or SDC: Device Clear or Selective Device Clear).** A Clear places the 3468A/B into its turn-on state. In addition, the SRQ Mask is set to zero or octal 200 (if the Power-On SRQ switch is on, see (paragraph 3-101).

3-75. **Remote.** The Remote Message allows the 3468A/B to be controlled over the HP-IL. In remote, the front panel buttons, except the LOCAL and Front Panel SRQ buttons, are disabled. The Local and Front Panel SRQ

buttons are disabled when the 3468A/B is in remote and local lockout (see paragraph 3-77). The instrument state in remote is determined by the local state before being placed in remote. The RMT annunciator on the display will also be on with the 3468A/B in remote.

**3-76. Local.** This message clears the remote operation of the 3468A/B and enables its front panel operation. Pressing the front panel LOCAL button also places the multimeter in the local state (if the button has not been disabled by the Local Lockout Message, see next paragraph).

**3-77. Local Lockout.** All the front panel buttons are disabled with this message, if the 3468A/B is in remote. The message is in effect until cleared over the HP-IL or power is cycled.

**3-78. Clear Lockout and Set Local.** This message placed the 3468A/B into local and the Local Lockout Message is cleared.

**3-79. Require Service (SRQ).** The Require Service Message (SRQ Message) is independent of all other HP-IL activity. The 3468A/B must be programmed to send the SRQ Message. This is done by programming the SRQ Mask (see paragraph 3-86). The front panel SRQ annunciator is on when the 3468A/B requires service.

3-80. Since more than one device (on the same Loop) can output the SRQ Message, the devices can be polled by the controller (by a Serial Poll) to determine if the 3468A/B (or another device) requires service. The 3468A/B then outputs a Status Byte (see paragraph 3-81) which shows for what reason the multimeter requires service.

**3-81. Status Byte.** The Status Byte is output by the 3468A/B in response to a Serial Poll. The message has the same information as the 3468A/B's Status Register (see next paragraph), and sets the corresponding bit true for any true SRQ condition shown in Table 3-4 (whether the SRQ Mask is set or not). The bit is represented in Figure 3-6.

3-82. The 3468A/B can require service if any condition in Table 3-3 is true. Since the SRQ Mask must be set to output the Require Service Message (except for bit 7, which is set by the Power-On SRQ switch), the 3468A/B's Status Register is used to monitor the conditions. This way, only the condition that is set by the mask outputs the SRQ Message. Other true conditions that can cause an SRQ Message, but which are not set in the SRQ Mask, remain in the Status Register as a true condition. They will not cause the SRQ Message to be output. For example, suppose the Front Panel SRQ condition is the only one set in the SRQ Mask. If the Data Ready condition is true, but not Front panel SRQ, no SRQ Message is output (the Status Register's Data Ready bit is true). The only way the SRQ Message is output is if the Front Panel SRQ condition is true. Both the Front panel SRQ bit and the Data Ready bit will then be true in the Status Register.

Table 3-3. Status Byte Definitions

Octal Code	Decimal Code	Bit	Definitions
001	1	0	Data Ready - Indicates to the controller that measurement data is ready to be output. The Require Service Message and bit is cleared when the controller begins to accept the data or when the reading is no longer available. See paragraph 3-110.
002	2	1	This bit will be true if the 3468A/B receives an invalid combination of range and function codes. The bit will be cleared when a valid combination is selected.
004	4	2	Syntax Error - This shows that an invalid Program Code(s) has been sent to the 3468A/B (e.g. F9).
010	8	3	Internal Error - Shows that a failure in the 3468A/B is detected. This may be a failure in the Self-Test Routine (see paragraph 3-56), the A/D Converter, or a checksum error in the Calibration RAM (checked every time a reading is taken). More information can be obtained by reading the 3468A/B's error register. See paragraph 3-116.
020	16	4	Front Panel SRQ - This bit is set when the 3468A/B's Front Panel SRQ button is pressed. See paragraph 3-111.
040	32	5	Invalid Calibration - When this bit is set, an attempt to calibrate the 3468A/B has failed.
100	64	6	This is the RQS bit. This bit is true only when the 3468A/B requires service from the controller.
200	128	7	Power-On SRQ - Shows that a power-on reset has occurred. See paragraph 3-102.

Note: More than one bit in the Status Byte can be true (see paragraph 3-83).

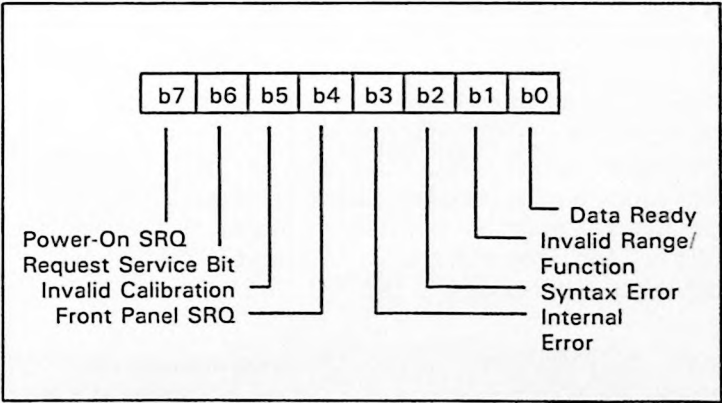
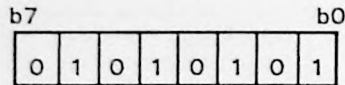


Figure 3-6. Status Byte

3-83. More than one bit in the Status Byte Message can be true. For example, bit 0, 2, and 4 are true (remember, bit 6 is true for any RQS condition, if the SRQ Mask is



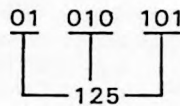
set for the condition) making the resultant Status Byte looks like the following:



#### NOTE

*A "1" in this example shows a true condition.*

3-84. The byte is output as shown in the previous example with the corresponding octal number of the example at 125 (shown as follows).



3-85. The Status Byte together with the Service Request (SRQ) Mask determine when the Require Service (RQS) bit is to be set. Setting RQS causes SRQ to be sent on the HP-IL. Execution of a Serial Poll for the 3468A/B will clear SRQ and it will remain clear until another reason for setting RQS occurs. RQS, on the other hand, is set if one or more corresponding bits in the Status Byte and SRQ Mask are both set. RQS is cleared whenever all corresponding bits are not both set. A Serial Poll then, may cause RQS to be cleared but not in all cases. Bits 2, 4, 5, and 7 are cleared with a Serial Poll.

3-86. **Programming the SRQ Mask.** The SRQ Mask must be set for the 3468A/B to output a Require Service Message. Setting the SRQ Mask will not set the bits in the Status Byte; these bits are automatically set (except bit 6) when any corresponding require service condition is true. For example, you wish to know if the multimeter has received an incorrect program code (Syntax Error) or has an internal failure (Internal Error). If the conditions are true, bits 2 and 3 of the Status Byte are set; but no Service Request Message is sent. The message will not be output until the SRQ Mask is set to the corresponding bits of the Status Byte (which are bits 2 and 3). Since the mask is to be set in octal, the resultant code for the bits is "14". The mask is set by sending "Mdd", where dd is the octal code for the bits.

3-87. Only bits 0 to 5 can be set by programming the SRQ Mask. Bit 6 of the Status Byte is set whenever the Require Service Message is output and bit 7 is set by the Power-On SRQ switch on the rear panel (see paragraph 3-101). Because of this, only a two digit octal code (00 to 77) can be sent to program the mask. The mask can be cleared by sending: "M00". Remember, the mask is only set to output a Require Service Message (not the Status Byte) for a certain SRQ condition.

3-88. **Status Bit.** The 3468A/B does not respond to a Parallel Poll. The Status Bit is used only for Parallel Poll and should not be confused with the bits in the Status Byte Message.

3-89. **Pass Control.** The 3468A/B does not have controller capabilities.

3-90. **Abort (Interface Clear).** All HP-IL communication is terminated (including the 3468A/B's Loop communication). Control is returned to the controller. The Abort Message does not remove the 3468A/B from remote control.

#### 3-91. 3468A/B Addressing

3-92. Each device in the loop is assigned an address by the controller. The assigned address will probably be different than the factory preset address. The 3468A/B, for example, has a preset address of 22. The address permits the controller to specify or select a particular device in the loop when sending commands. Addresses are assigned sequentially around the loop in the direction of information flow. The first device in the loop, after the controller, is assigned an address of 1. The second device in the loop is assigned an address of 2, and so on around the loop until all devices have been addressed. If the 3468A/B is the only device in the loop with the controller, it will be assigned an address of 1.

3-93. Refer to Figure 3-7. It shows a controller and four devices with their basic capabilities, assigned loop addresses, and the direction of information flow. Remember that the controller automatically assigns addresses to devices in the loop.

#### 3-94. Talk-Only Mode (No Controller)

3-95. The 3468A/B's Talk-Only Mode allows the multimeter to send measurement data to an external device (like a printer) without a Loop controller. The multimeter is placed into the Talk-Only Mode by setting switch 1 (on the 3468A/B rear panel) to 1 (up). Measurement data is then output after each trigger. Function and range settings are selected from the front panel.

#### NOTE

*The rear panel switches can be externally set without instrument disassembly by doing the following:*

1. *Bring the rear panel under a light source to locate the switches inside the instrument. Determine which switch you want changed.*
2. *Insert a small blade screwdriver or awl through the appropriate opening on the rear panel.*
3. *Place the screwdriver or awl below or above the switch rocker, dependent on the position of the rocker. Push the rocker up or down.*

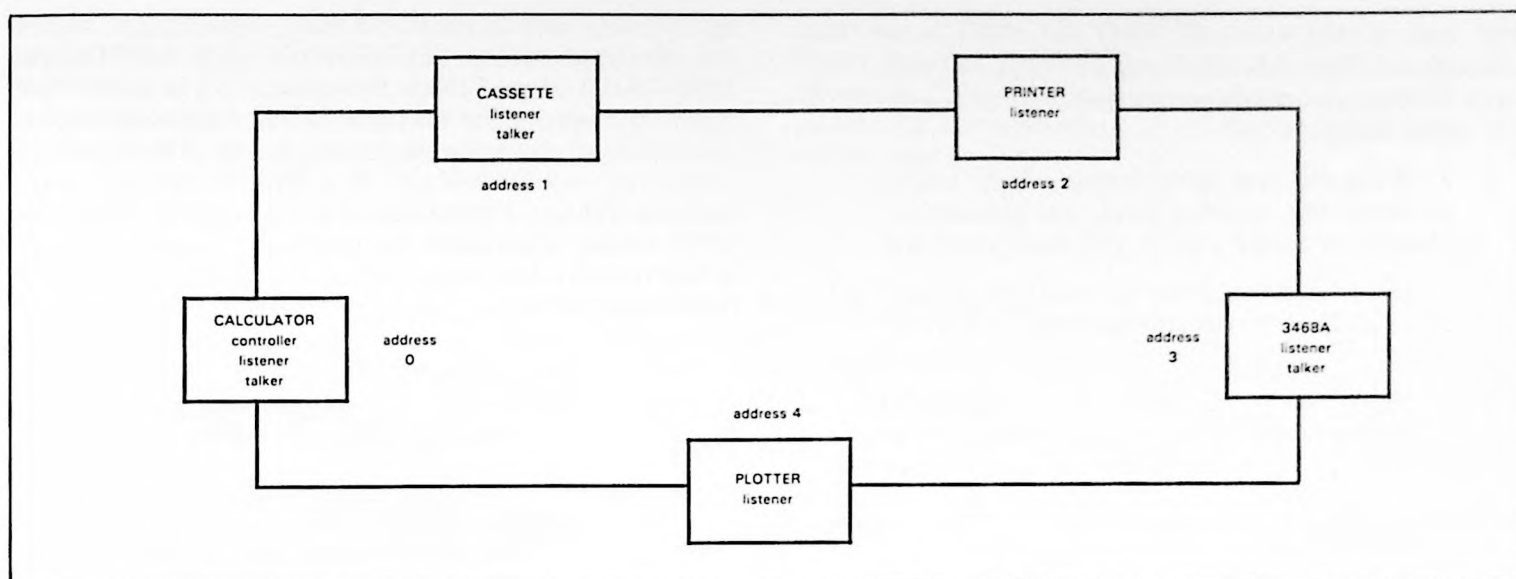


Figure 3-7. HP-IL Addressing

### 3-96. 3468A/B HP-IL Programming

**3-97. General.** The following paragraphs explain how to program the 3468A/B over the HP-IL. If information is desired using controller dependent language, refer to the 3468A/B's Operator's Manual.

**3-98.** Programming the 3468A/B is done by DATA messages. Set-up information (Range, Function, etc.) is DATA sent by the controller and is done using program codes. The DATA received by the controller (from the 3468A/B) is measurement data, and as well as other data like the Status Byte and the 5 bytes from the Output Binary Status Byte.

**3-99. Program Codes.** All the program codes for the 3468A/B are listed in Table 3-4. The 3468A/B must be in "remote" and "listen" to receive the codes (the RMT and LSTN annunciators are on when the 3468A/B is in remote and listening).

**3-100.** The Program Codes are a series of 8-bit ASCII characters. All lower case characters, spaces, commas, and semicolons are ignored (they may be used with the codes as separators). All null characters, carriage return, line feed, form feed, vertical tab, and horizontal tab characters are also ignored. Other characters which are not included in Table 3-4, cause a Syntax Error (bit 2 in the Status Register set). In addition, a Syntax Error is caused if the characters are sent in a different order than shown in the table (e.g. "1F" causes a Syntax Error).

**3-101. Power-On SRQ.** This feature is enabled by setting the Power-On SRQ switch to On (switch #3 on the rear panel in the up position). When the feature is en-

abled, the 3468A/B Requests Service (generates an SRQ) each time power is cycled or a reset condition is generated by the instrument (e.g. due to an instrument failure or selecting the Self-Test).

Table 3-4. 3468A/B Program Codes

Type	Program Code	Description
FUNCTION	F1	DC Volts
	F2	AC Volts
	F3	2-Wire Ohms
	F4	4-Wire Ohms
	F5	DC Current
	F6	AC Current
	F7	Extended Ohms (see paragraph 3-110)
RANGE	R1	.3V, 300 Ohm, .3 Amp, Extended Ohms
	R2	3V, 3K Ohm, 3 Amp (AC only)
	R3	30V, 30K Ohm
	R4	300V, 300K Ohm
	R5	3M Ohm
	R6	30M Ohm
DIGITS DISPLAYED	N3	3 1/2 Digits Displayed
	N4	4 1/2 Digits Displayed
	N5	5 1/2 Digits Displayed
TRIGGER	T1	Internal Trigger
	T2	Single Trigger
AUTOZERO	Z0	Autozero Disabled
	Z1	Autozero Enabled
DISPLAY	D1	Normal Display Operation
	D2	Display Text and update Annunciators
MISC. COMMANDS	B1	Read Status of the 3468A/B in Binary (see paragraph 3-115)
	C	Calibrate (see Section IV of this manual)
	Mdd	Set SRQ Mask (Mdd, where dd is the octal code of the bits)



**NOTE**

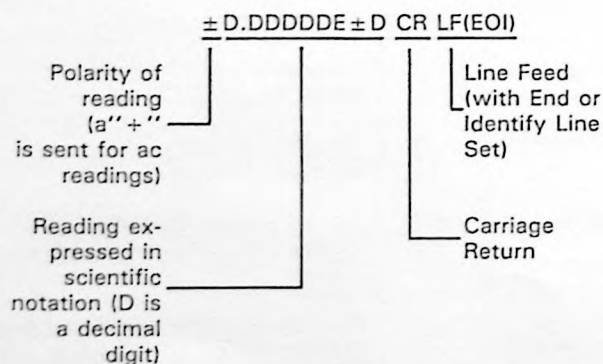
*The rear panel switches can be externally set without instrument disassembly by doing the following:*

1. Bring the rear panel under a light source to locate the switches inside the instrument. Determine which switch you want changed.
2. Insert a small blade screwdriver or awl through the appropriate opening on the rear panel.
3. Place the screwdriver or awl below or above the switch rocker, dependent on the position of the rocker. Push the rocker up or down.

**3-102. Sending Data to the Display.** Up to 12 ASCII characters can be displayed at a time by the 3468A/B's display. The legal characters are decimal 32 through 95 of the 128 ASCII characters. Only upper case letters and numbers can be displayed. Lower case letters generate characters which do not resemble the letters. Commas, periods, and semicolons can go between characters.

**3-103.** The display message mode is enabled by program code "D2" (e.g. "D23468 DMM" where "3468 DMM" is the message displayed). In this mode, the annunciators continue to be updated. If more than 12 characters are sent to the display, the extra characters are ignored until a control character is received. If the control character is different than HT (Horizontal Tab), VT (Vertical Tab), LF (Line Feed), CR (Carriage Return), or FF (Form Feed), a Syntax Error is generated. A "D2" code locks the display until a "D1" (Selects Normal Display) is sent, a CLEAR message is sent, an error condition occurs, or a front panel button is pressed.

**3-104. Reading Data from the 3468A/B.** Data in the form of readings can be output by the 3468A/B over the HP-IL (other data that can be output is discussed in later paragraphs). To output a reading (if available), the 3468A/B has to be addressed to "talk". The readings are output using 13 ASCII characters and are in the following form.



**3-105.** Each character in the output statement (except EOI) is one byte, which adds up to 13. The exponent will be in engineering notation (E-3, E+0, E+3, or E+6)

and the mantissa will always have 1, 2, or 3 digits before the decimal point (D.DDDDD, DD.DDDD, or DDD.DDD). If the 3468A/B is in the 4 1/2 or 3 1/2 Digit mode, the 5th and/or 6th digits will be output as zeroes. An overload condition (whether plus or minus) will be output as: +9.99999E+9. If a different output is requested (Binary, Front/Rear Switch position, etc.), the other output supercedes the reading. If a data transfer is interrupted while being output, the 3468A/B continues the output wherever it left off, when addressed again. This partial output (or any output) can be disabled by a Group Execute Trigger (GET), Clear Message (DCL or SDC), sending any valid program code, or pressing the LOCAL, SHIFT, and TEST/RESET buttons on the front panel.

**3-106. Data Ready Feature.** The Data Ready feature of the 3468A/B, when enabled, outputs a Service Request Message (SRQ) after each completed measurement cycle. Before the message can be output, bit 0 of the SRQ Mask must be set. This is done by sending program code "M01" (bit 0 of the Status Byte and Status Register). When the Service Request Message is sent, the front panel "SRQ" annunciator turns on and bit 0 of the Status Byte is set. The SRQ condition remains until the data is read by the controller, or a Serial Poll is done.

**3-107. Front Panel SRQ.** The Front Panel SRQ feature of the 3468A/B outputs a Service Request Message (SRQ) each time the Front Panel SRQ button is pressed. Before the message can be output, bit 4 of the SRQ Mask must be set. This is done by sending program code "M20" (bit 4 of the Status Byte and Status Register). Once this is done, the Service Request Message will be output and the front panel SRQ annunciator turns on, whenever the SRQ button is pressed. The SRQ condition remains until a Serial Poll is done by the Controller.

**3-108. Advanced Programming**

**3-109. General.** The following paragraphs have advanced programming information for the 3468A/B. It includes Extended Ohms Operation and Reading the Binary Status Byte.

**3-110. Extended Ohms Operation.** This operation (or function) is only available over the HP-IL and is used to measure resistance above 30M ohm. The function is selected by sending program code "F7R1". The 3468A/B is set to the 2-Wire Ohms Function and the 30M ohm Range. A 10M ohm resistor is connected in parallel with the input. Measure the internal resistor first and then measure the unknown resistance. The unknown resistance can then be calculated by this formula:

$$R_x = \frac{R_i \cdot R_t}{R_i - R_t}$$

where  $R_x$  is the unknown resistance,  $R_i$  is the measured 10M ohm resistor, and  $R_t$  is the measured value of the parallel combination.

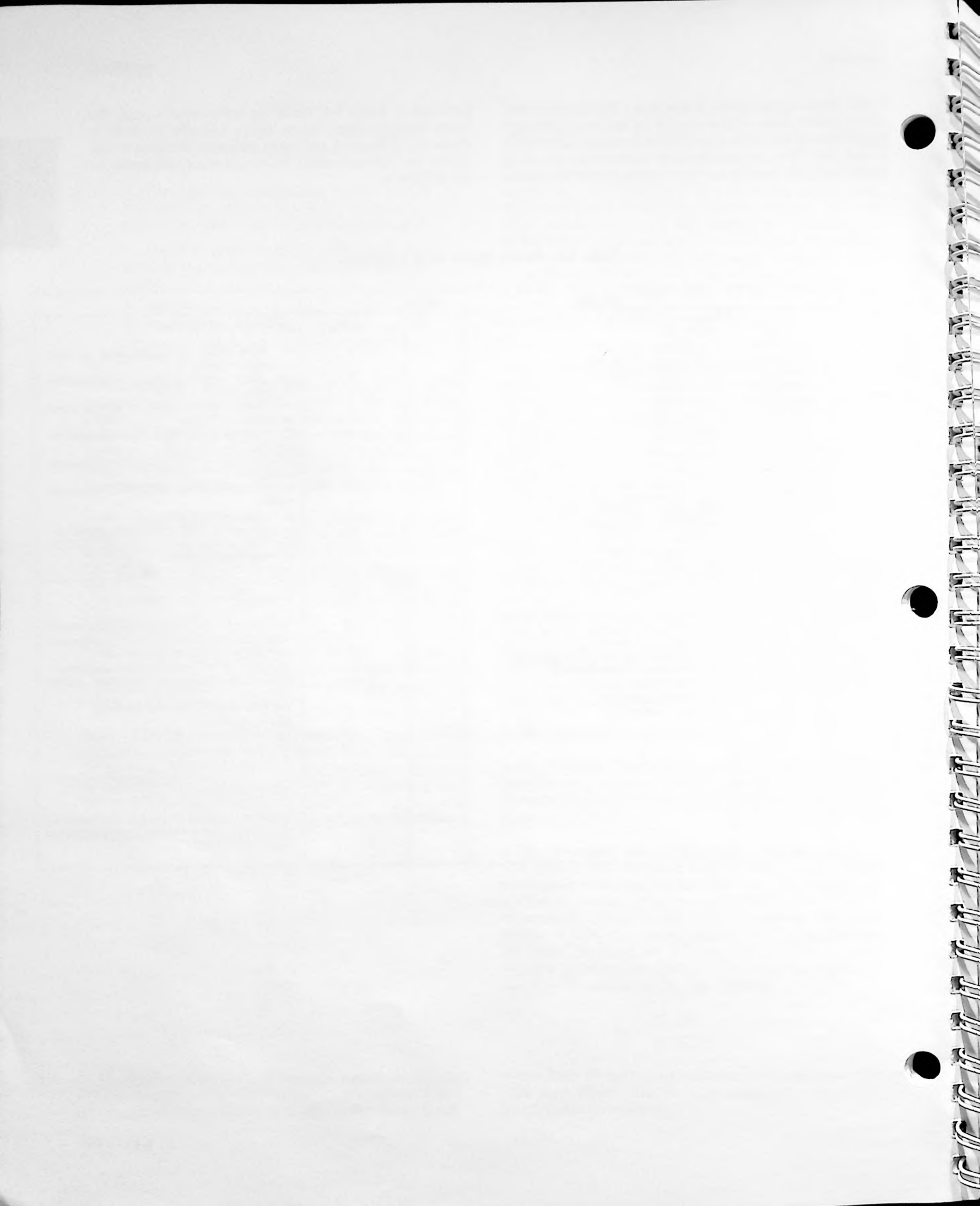
**3-111. Reading the Binary Status Byte.** The current state of the 3468A/B can be determined by reading the Binary Status Byte of the instrument. When program code "B1" is sent, the 3468A/B outputs five bytes which are each 8 bits wide. The corresponding meaning of the bits (when

true) are in Table 3-5. Once the status byte is read, the Error Register (byte 4; see Table 3-5) will be cleared. However, if the error still exists and the instrument is triggered, the corresponding bit of the error will again be set in byte 4.

**Table 3-5. Binary Status Byte Definition.**

Byte #		Definition	Byte #		Definition
1	Bits True	Function, Range, and Number Of Digits Displayed	3	Bit#	SRQ Mask Bit Definition
	XXXXXX01	5 1/2 Digits Displayed		0	1 = Data Ready bit set for SRQ on each complete reading
	XXXXXX10	4 1/2 Digits Displayed		1	1 = SRQ when invalid range/function combination
	XXXXXX11	3 1/2 Digits Displayed		2	1 = Syntax Error - SRQ if Syntax Error occurs
	XXX001XX	Same as R1		3	1 = Internal Error - SRQ if Hardware Error occurs
	XXX010XX	Same as R2		4	1 = Front Panel SRQ - SRQ if SRQ button is pressed
	XXX011XX	Same as R3		5	1 = Calibration Error - SRQ if CAL procedure failed
	XXX100XX	Same as R4		6	Not used (always 0)
	XXX101XX	Same as R5		7	1 = Power-On SRQ - PON SRQ switch on last time power was turned on or DCL message was received
	XXX110XX	Same as R6	4	Bit#	Internal Error Information
	XXX111XX	Same as R7		0	Set if any of the Calibration RAM locations have incorrect checksums or if a range with an incorrect checksum is selected
	001XXXXX	DC Volts Function		1	The Main CPU RAM Self-Test has failed
	010XXXXX	AC Volts Function		2	The ROM Checksum incorrect during Self-Test
	011XXXXX	2-Wire Ohms Function		3	An A/D Slope Error was detected
	100XXXXX	4-Wire Ohms Function		4	Not used (always 0)
	101XXXXX	DC Current Function		5	Not used (always 0)
	110XXXXX	AC Current Function		6	Not used (always 0)
	111XXXXX	Extended Ohms Function		7	Not used (always 0)
2	Bit#	Instrument Status Bits	5		A/D DAC Value
	0	1 = Internal Trigger, 0 = single Trigger			A decimal value between 0 to 63 represents the setting of the internal Digital to Analog Converter (DAC).
	1	1 = Autorange Enabled			
	2	1 = Autozero Enabled			
	3	1 = 3468A/B set for 50Hz Operation			
	4	1 = Calibration RAM Enabled			
	5	Not used (always 0)			
	6	Not used (always 0)			
	7	Not used (always 0)			





## SECTION IV

### PERFORMANCE TEST AND CALIBRATION

#### 4-1. INTRODUCTION

4-2. This section of the manual has the Performance Tests and Calibration Procedures used to verify the 3468A/B's accuracy specifications, and to calibrate the multimeter to those specifications. A summary of the specifications to which the 3468A/B is tested and calibrated is listed in Table 4-1. The complete specifications are in Table 1-1. All tests and calibrations are made without removing any instrument covers.

4-3. Since Performance Tests are normally performed after calibration, the tests are included in the Calibration Procedures. The procedures are set up in such a way that the Performance Tests can be ignored, if so desired.

#### 4-4. EQUIPMENT REQUIRED

4-5. All required test equipment for the Performance Tests and Calibration Procedures are listed in Table 4-2 (Recommended Test Equipment). The equipment used for the individual tests and the test procedures are also listed at the beginning of each test procedure. If any of the recommended equipment is not available, use

substitute equipment. A short description of the required equipment and the critical specifications necessary to do the test and calibration procedures is in the following paragraphs. This information may be helpful in choosing substitute equipment.

#### 4-6. DC Volts Test and Calibration

4-7. The DC Volts Test and Calibration (DC Volts Function) requires a very accurate Digital Voltmeter (like the 3456A) as the Standard. The Digital Voltmeter must be calibrated to its 24 hour dc volts specifications before calibrating and testing the 3468A/B (i.e. the 3468A/B is tested and calibrated within 24 hours after the Digital Voltmeter, which is used as the standard, has been calibrated). It is recommended that the Digital Voltmeter be calibrated in the same temperature environment and leave the Digital Voltmeter in the same temperature environment in which the 3468A/B is to be calibrated and tested (e.g. the 3468A/B's Reference Temperature, see Paragraph 4-39). In addition to the Digital Voltmeter, a DC Volts Standard is required to be used as a very stable voltage source. The following lists the required equipment and recommended models.

Table 4-1. Abbreviated Specification Table

DC Volts Function (accuracy = $\pm$ (% of reading + number of counts))				AC Volts Function 1 Year Limits (accuracy = $\pm$ (% of reading + number of counts))			
Range	24 Hour Limits	90 Day Limits	1 Year Limits	Frequency	.3V Range	3V,30V Range	300V Range
.3V	0.005 + 4	0.009 + 5	0.02 + 5	20Hz- 50Hz	1.14 + 163	1.14 + 102	1.18 + 102
3V	0.0035 + 2	0.007 + 2	0.018 + 2	50Hz-100Hz	0.46 + 163	0.46 + 103	0.50 + 102
30V	0.005 + 3	0.009 + 3	0.02 + 3	100Hz- 20KHz	0.29 + 163	0.26 + 102	0.33 + 102
300V	0.0055 + 2	0.009 + 2	0.02 + 2	20KHz- 50KHz	0.56 + 247	0.41 + 180	0.55 + 180
				50KHz-100KHz	1.74 + 882	1.05 + 825	1.26 + 825
				100KHz-300KHz	N/A	10.1 + 3720 (30V Range only)	N/A
DC Current Function (accuracy = $\pm$ (% of reading + number of counts))				AC Current Function 1 Year Limits (accuracy = $\pm$ (% of reading + number of counts))			
Range	90 Day Limits	1 Year Limits		Frequency	.3A Range	3A Range	
3A < 1A	0.14 + 6	0.17 + 6		20 Hz 50 Hz	1.77 + 163	2.5 + 163	
3A > 1A	1.0 + 30	1.0 + 30		50 Hz 1KHz	1.1 + 163	1.8 + 163	
				1KHz 10KHz	1.0 + 163	1.7 + 163	
				10KHz 20KHz	1.14 + 163	1.84 + 163	
Ohms Function (accuracy = $\pm$ (% of reading + number of counts))							
Range	24 Hour Limits	90 Day Limits	1 Year Limits				
300	0.0045 + 4	0.012 + 5	0.017 + 5				
3K	0.0035 + 2	0.011 + 2	0.016 + 2				
30K	0.0035 + 2	0.011 + 2	0.016 + 2				
300K	0.0035 + 2	0.011 + 2	0.016 + 2				
3M	0.0052 + 2	0.011 + 2	0.016 + 2				
30M	0.036 + 2	0.066 + 2	0.078 + 2				



**Table 4-2. Recommended Test Equipment.**

Instrument	Critical Specifications	Recommended Model	Use*
Digital Voltmeter	Range:300mV to 300V Accuracy: $\pm .004\%$ (30V,300V) $\pm .005\%$ (300mV,3V)	-hp- Model 3456A	PCT
DC Voltage Standard	Voltage:300mV to 300V Accuracy: $\pm .005\%$	Systron Donner Model M107	PCT
AC Calibrator	Frequency:20Hz to 300KHz Voltage:30mV to 300V Accuracy: $\pm .1\%$ Voltage Stability: $\pm .02\%$	Fluke Model 5200A and Model 5215A	PCT
AC/DC Current Source	DC Current:1A Accuracy: $\pm .03\%$ AC Current:100mA to 1A Frequency:1KHz to 5KHz Accuracy: $\pm .1\%$	Valhalla Model 2500	PCT
Resistance Standard	Resistance:100 ohm Accuracy: $\pm .0005\%$	Guildline Model: 9330/100 or 9330A/100	PC
	Resistance:1K ohm Accuracy: $\pm .0005\%$	9330/1K or 9330A/1K	PC
	Resistance:10K ohm Accuracy: $\pm .001\%$	9330/10K or 9330A/10K	PC
	Resistance:100K ohm Accuracy: $\pm .001\%$	9330/100K or 9330/100K	PC
	Resistance:1M Accuracy: $\pm .01\%$	9330/1M	PC
	Resistance:10M Accuracy: $\pm .01\%$	9330/10M	PC
Desktop Computer	HP-IB Capability	-hp- Model 85, 9825,9826,9835,or 9845	CTO
Bus System Analyzer	HP-IB Control Capability	-hp- Model 59401A	T
Oscilloscope	Bandwidth:DC to 100MHz	-hp- Model 1740A	T
Signature Analyzer		-hp- Model 5004A	T
*P=Performance    C=Calibration    T=Troubleshooting    O=Operator's Check			

**4-8. Digital Voltmeter.** The recommended Digital Voltmeter is an -hp- Model 3456A. The critical requirements are as follows:

- Required voltage range is from 300mV to 300V dc.
- Accuracy and stability requirements in a 24 hour period are as follows:

$\pm .004\%$  for the 30V and 300V Ranges

$\pm .005\%$  for the 300mV and 3V Ranges

**4-9. DC Volts Standard.** The DC Volts Standard chosen is a Systron Donner Model M107 Precision Voltage Source. The critical requirements are as follows:

- Output from 300mV to 300V dc.
- Within .005% full scale accuracy.
- Short term stability better than .0002% per hour.

#### 4-10. AC Volts Test and Calibration

4-11. For the AC Volts Test and Calibration (AC Volts Function) use the Fluke Model 5200A/5215A AC Calibrator. If the calibrator is not available, use a substitute calibrator that meets the requirements listed following this paragraph. It is suggested to acquire the recommended calibrator with the HP-IB (IEEE 488) option 05 for future computerized Performance Test and Calibration.

- Frequency Response: 20Hz to 100KHz (and 300KHz at 30V).
- AC Volts Range: 300mV to 300V ac.
- AC Volts Accuracy:  $\pm .1\%$ .

#### 4-12. Ohms Test and Calibration

4-13. The 3468A/B's Ohms Function can be tested and calibrated in two different ways, at full scale or 1/3 scale.

If the 3468A/B is to be tested and calibrated at full scale, use three each of the recommended standard resistors in series to form, 300ohm, 3Kohm, etc. If the 3468A/B is to be tested and calibrated at 1/3 scale, use only one each of the recommended standard resistors.

4-14. If the recommended resistors are not available, use substitutes that meet the critical requirements. If a substitute is not available, you may be able to use a calibrated decade resistor with settings that range from 300 ohm to 30M ohm or 100 ohm to 10M ohm. The correction factors on the decade resistor's calibration chart must be algebraically added to the 3468A/B reading, to achieve the required accuracy. The Standard Resistors and critical requirements are as follows:

a. **100 ohm, and 1K ohm Standard Resistors.** Use the Guildline Model 9330/100 or 9330A/100 for the 300 ohm Range, and Model 9330/1K or 9330A/1K for the 3K ohm Range. The accuracy requirement is  $\pm .0005\%$  or better.

b. **10K ohm and 100K ohm Standard Resistors.** Use the Guildline Model 9330/10K or 9330A/10K for the 30K ohm Range and Model 9330/100K or 9330A/100K for the 300K ohm Range. The accuracy requirement is  $\pm .001\%$  or better.

c. **1M ohm Standard Resistor.** Use the Guildline Model 9330/1M for the 3M ohm Range with  $\pm .002\%$  or better accuracy.

d. **10M ohm Standard Resistor.** Use the Guildline Model 9330/10M for the 30M ohm Range with  $\pm .01\%$  or better accuracy.

#### 4-15. DC Current Test and Calibration

4-16. The DC Current Test and Calibration requires an AC-DC Current Calibrator as the current source, a Digital Voltmeter for the standard, and a DC Volts Standard for a stable voltage source. The following paragraphs have the required equipment and recommended models.

4-17. **AC-DC Current Source.** The Valhalla Model 2500 is the recommended AC-DC Current Source. The critical requirements are as follows:

- a. Required current is 1A.
- b. Required accuracy is  $\pm .03\%$ .

4-18. **Digital Voltmeter.** The recommended Digital Voltmeter is an -hp- Model 3456A. Refer to paragraph 4-8 for the critical requirements.

4-19. **DC Volts Standard.** The DC Volts Standard chosen is a Systron Donner Model M107 Precision Voltage Source. Refer to paragraph 4-9 for the critical requirements.

#### 4-20. AC Current Test and Calibration

4-21. The AC Current Test and Calibration requires an AC-DC Current Calibrator as the current source and an AC Calibrator as the ac standard. The following paragraphs have the required equipment and recommended models.

4-22. **AC-DC Current Source.** The Valhalla Model 2500 is the recommended AC-DC Current Source. The critical requirements are as follows:

- a. Required current is 100mA and 1A.
- b. Required frequency response is: 1KHz and 5KHz
- c. Required accuracy is  $\pm .03\%$ .

4-23. **AC Calibrator.** The recommended AC Calibrator is a Fluke Model 5200A/5215A. Refer to paragraph 4-11 for the critical requirements.

#### 4-24. TEST CARDS

4-25. Performance Test Cards are provided at the end of this section and are to be used to record the 3468A/B's performance. It is recommended to fill out the cards and refer to them while doing the test. The test limits and set-up information are printed on the cards for easy reference. The cards can therefore be used as an abbreviated test procedure (if you are familiar with the test procedures). The cards can also be used as a permanent record and may be reproduced without written permission from Hewlett-Packard.

#### 4-26. CALIBRATION CYCLE

4-27. A periodic performance verification is required for the 3468A/B. This should be done as part of an incoming inspection test and at a 90 day or 1 year interval, depending on your environmental condition and accuracy requirements.

#### 4-28. TEST FAILURE

4-29. If the 3468A/B fails any Performance Test, do the necessary calibration according to which test failed (e.g. do the DC Volts Calibration for a DC Volts Test failure). If only one range fails, calibrate only that range, otherwise calibrate the complete function (this is only true for the DC Volts and Ohms Functions). If the failure cannot be corrected by calibration, go to Section VII of this manual for servicing information.

#### 4-30. INSTRUMENT SET-UP

4-31. Instrument set-up is specified in each test and calibration procedure.

#### 4-32. INSTRUMENT SPECIFICATION

4-33. Specifications are the performance characteristics of the instrument which are certified. These specifica-



tions, listed in Table 1-1 and Table 4-1, are the performance standards or limits against which the 3468A/B can be tested. Table 1-1 also lists some supplemental characteristics of the 3468A/B and should be considered as additional information.

4-34. Any changes in the specifications due to manufacturing changes, design, or traceability to the National Bureau of Standards will be covered in a manual change supplement or revised manual. The specifications listed here supercede any previously published.

#### 4-35. Specification Breakdown

4-36. The 3468A/B's specifications are grouped according to instrument function (AC Volts, DC Volts, etc.). Within each group are either one, two, or three main sets of specifications: the 24 hour, 90 day, and 1 year limits. The limits to which the 3468A/B conforms depend on when the instrument was last calibrated. They also depend on the limits to which the 3468A/B was certified and also on the instrument function. The 24 hour limits should only be used if the instrument was calibrated within the last 24 hours, otherwise, the 90 day or 1 year limits apply.

4-37. Each set of specifications includes an accuracy specification for each voltage, ohms, and current range. They are specified as a percentage of the reading and an add-on of a certain number of counts. For example, the 24 hour full scale DC Volts Function accuracy on the 30V Range (in the 5 Digit Display mode) is:

$$\pm .005\% \text{ of reading} + 3 \text{ counts}$$

giving a full scale accuracy of  $\pm .005\%$  or (5 counts) plus 3 counts (or  $.003\%$ ), which is a total of 8 counts (or  $\pm .008\%$ ). (This is only true at full scale and changes at 1/10 scale, see next paragraph.) If for example the 4 Digit Display mode is selected, the percentage is the same ( $.005\%$ ), but the number of counts is different and changes the total percentage to  $\pm .015\%$  ( $.005\%$  plus 1 count in the 4 Digit mode is  $.01\%$  which makes the total equal  $.015\%$ ).

4-38. The number of counts also changes the accuracy of the 3468A/B at 1/10 scale. For example, the percentage (same Function, Range, and Digit mode) at 1/10 scale is still  $.005\%$  at 1/10 scale. However, the number of counts (3) is  $.03\%$  at 1/10 scale. This gives a total of  $.035\%$ , rather than  $.008\%$  at full scale.

#### 4-39. Temperature Coefficient (Reference Temperature)

4-40. The temperature in which the 3468A/B was last calibrated is called its Reference Temperature. To maintain the 3468A/B's specified accuracy, the multimeter must be operated within the specified range of that temperature (as shown in Table 1-1). If the 3468A/B is tested or operated outside the temperature range, the

Temperature Coefficient (listed in Table 1-1) must be added to the instrument's specifications. It is recommended to calibrate the 3468A/B in the temperature in which it is to be tested and operated.

#### 4-41. TEST CONSIDERATION

##### 4-42. General

4-43. Because the 3468A/B is able to make highly accurate dc measurements, certain requirements have to be met. For example, the Digital Voltmeter used to test and calibrate the 3468A/B should be good enough so that its errors do not introduce any significant uncertainties in the Performance Test and Calibration. A Voltmeter which is 10 times better than the 3468A/B nearly eliminates the uncertainties. Since voltmeters (or even standards) with these accuracies are not readily available, use the recommended Digital Voltmeter. Make sure the voltmeter has been calibrated to its 24 hour specifications and used within 24 hours after calibration, before testing and calibrating the 3468A/B.

##### 4-44. Ambiguous Region

4-45. Since the available test equipment is not an order of magnitude better than the 3468A/B, it is important to be aware of the uncertainties or "ambiguities". An example is in the next paragraph.

4-46. A hypothetical case is to check the 3468A/B's 3V full scale dc accuracy with a certain standard. The 3468A/B's 90 day specification is  $\pm .01\%$  with the standard's accuracy ideally  $\pm .001\%$  (ten times better). If the 3468A/B reading is "30.0033" ( $.011\%$  high), the multimeter may or may not meet the 90 day limit (dependent on the standard's accuracy). If the standard is  $.001\%$  high (30.0003V), the 3468A/B's actual reading is "30.0030" which is in the 90 day limit. If the standard output is right on, the 3468A/B reading is "30.0033" (its reading is high and out of tolerance). Although in both instances the standard is within its limits, it may show the 3468A/B to be in or out of its limits. This creates an Ambiguous Region, shown in Figure 4-1. The region gets bigger when the 3468A/B limits are tighter and/or the standard's specifications are less accurate. The best test is when you know your standard's actual limits.

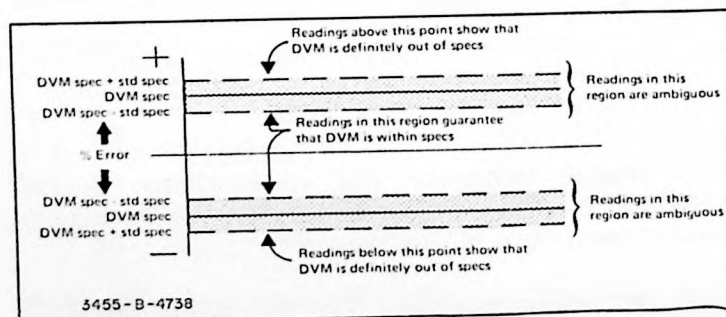


Figure 4-1. Ambiguous Regions

## 4-47. PERFORMANCE TEST

4-48. The Performance Test is separated into five main tests: DC Volts, DC Current, AC Volts, AC Current, and Ohms. Each step in the tests and the tests themselves should be done in the order they are given, starting with the DC Volts Test. Allow at least a 1 hour warm-up time. If the 3468A/B has been on for less time, inaccuracies can result. The Performance Test is separated into the following tests.

- DC Volts Test - paragraph 4-49.
- DC Current Test - paragraph 4-54.
- AC Volts Test - paragraph 4-59.
- AC Current Test - paragraph 4-64.
- Ohms Test - paragraph 4-69.

## 4-49. DC Volts Test

4-50. The DC Volts Test limits are printed on the DC Volts Test Card and in Table 4-3. The instrument set-up information is also printed on the test card. Each step on the test card corresponds to a step in the test procedure. Because of this, each step number on the test card is shown in parenthesis (e.g., Step #1.) in the procedure.

4-51. Unless otherwise specified, all test signals are applied to the 3468A/B's HI and LO INPUT Terminals.

4-52. **Equipment Required.** The following is the required test equipment for the DC Volts Test.

Digital Voltmeter (-hp- Model 3456A)

DC Volts Standard (Systron Donner Model M107)

4-53. **Test Procedure.** After the 3468A/B has been warmed up for at least one hour, do the following:

- (Step #1.) Reset the 3468A/B by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

## NOTE

*Resetting the 3468A/B, automatically places the instrument into the DC Volts Function, Autorange, Internal Trigger, and 5 Digits Displayed.*

b. (Step #2.) Short the 3468A/B's INPUT Terminals. The instrument should now be on the .3V Range.

c. Record the displayed reading on the Test Card and make sure the reading is within the limits shown on the Test Card and in Table 4-3.

d. (Step #3, 4, and 5.) Set the 3468A/B to the 3V, 30V, and 300V Range by pressing the Uprange button once for each range. Record and make sure the reading on each range is within the specified limits. If any readings in this step or step c are out of the specified limits, go to the DC Volts Calibration Procedure in paragraph 4-86.

e. (Step #6.) Remove the short from the 3468A/B's INPUT Terminals and set the multimeter to the .3V Range.

f. Set the DC Volts Standard for zero volts output. Set the Digital Voltmeter to the DC Volts Function and Autorange.

g. Connect the 3468A/B to the Digital Voltmeter and DC Volts Standard, as shown in Figure 4-2. Use the Digital Voltmeter as the standard and the DC Standard as the power supply. An example on how the Digital Voltmeter and DC Volts Standard checks the 3468A/B accuracy using the multimeter's 3V Range, is as follows:

- Set the 3468A/B to the 3V Range.
- Set the DC Volts Standard for an output of +3V.

Table 4-3. DC Volts Test Limits

3468A/B Input	3468A/B Range	3468A/B Set Up	24 Hour Limits		90 Day Limits		1 Year Limits	
			high	low	high	low	high	low
Short	.3V	DCV	+000004V	-000004V	+000005V	-000005V	+000005V	-000005V
Short	3V		+0.00002V	-0.00002V	+0.00002V	-0.00002V	+0.00002V	-0.00002V
Short	30V		+00.0003V	-00.0003V	+00.0003V	-00.0003V	+00.0003V	-00.0003V
Short	300V		+000.002V	-000.002V	+000.002V	-000.002V	+000.002V	-000.002V
300mV	.3V		+0.300019V	+0.299981V	+0.300032V	+0.299968V	+0.300065V	+0.299935V
300mV	3V		+0.30003V	+0.29997V	+0.30004V	+0.29996V	+0.30007V	+0.29993V
+1V	3V		+1.00006V	+0.99994V	+1.00009V	+0.99991V	+1.00020V	+0.99980V
-1V	3V		-1.00006V	-0.99994V	-1.00009V	-0.99991V	-1.00020V	-0.99980V
-3V	3V		-3.00013V	-2.99987V	-3.00023V	-2.99977V	-3.00056V	-2.99942V
+3V	3V		+3.00013V	+2.99987V	+3.00023V	+2.99977V	+3.00056V	+2.99944V
+3V	3V	AZ Off	+3.00016V	+2.99984V	+3.00026V	+2.99974V	+3.00059V	+2.99941V
+3V	3V	AZ On, 4 Digit	+3.0002V	+2.9998V	+3.0003V	+2.9997V	+3.0006V	+2.9994V
+3V	3V	3 Digit	+3.001V	+2.999V	+3.001V	+2.999V	+3.002V	+2.998V
+3V	30V	5 Digit	+03.0005V	+02.9995V	+03.0006V	+02.9994V	+03.0009V	+02.9991V
+10V	30V		+10.0008V	+09.9992V	+10.0012V	+09.9988V	+10.0023V	+09.9977V
+30V	30V		+30.0018V	+29.9982V	+30.0030V	+29.9970V	+30.0063V	+29.9937V
+30V	30V	AZ Off	+30.0029V	+29.9971V	+30.0041V	+29.9959V	+30.0074V	+29.9926V
+300V	300V	AZ On	+300.019V	+299.981V	+300.029V	+299.971V	+300.062V	+299.938V

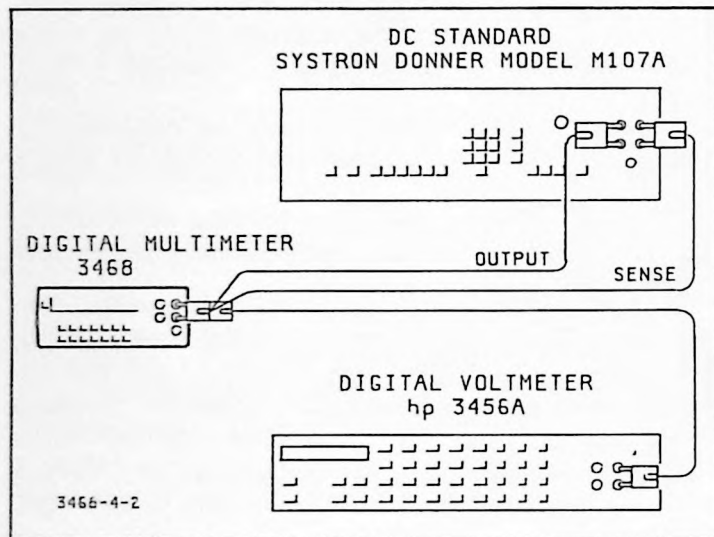


3. Note the reading on the Digital Voltmeter. If the reading is not exactly +3V, adjust the DC Volts Standard until the reading is exactly +3V, as displayed by the Digital Voltmeter. This reading is then the standard voltage used to check the 3468A/B reading.

4. Make sure the 3468A/B reading is within its specified limits. Record the reading on the Test Card.

#### NOTE

*Always uprange the 3468A/B before upranging the DC Volts Standard and always downrange the DC Volts Standard before downranging the 3468A/B.*



**Figure 4-2. DC Volts Accuracy Test**

h. Check the multimeter's .3V Range full scale accuracy by setting the DC Volts Standard for an accurate output (as displayed on the Digital Voltmeter) of 300mV. Check the multimeter's reading and make sure it is within the specified limits.

i. (Step #7.) Set the 3468A/B to the 3V Range and set the DC Volts Standard for an accurate output of +300mV. Check and record the reading.

j. (Step #8.) Set the DC Volts Standard for a +1V output. Check and record the reading.

k. (Step #9.) Apply -1V to the 3468A/B by reversing the input leads. (Leave the leads in that position for the next step.) Check and record the reading.

l. (Step #10.) Set the DC Volts Standard for a 3V output (-3V input to the 3468A/B). Check and record the readings.

m. (Step #11.) Apply +3V to the 3468A/B by reversing the input leads. (Leave the leads in that position for the steps that follow.) Check and record the readings.

n. (Step #12.) With +3V applied to the 3468A/B, turn Autozero off by pressing the blue Shift button and then the INT/TRIG (AUTO/ZERO) button. Check and record the reading.

o. (Step #13.) Turn Autozero on by pressing the blue Shift button and then the INT/TRIG (AUTO/ZERO) button.

p. (Step #14.) With +3V applied to the 3468A/B, select the multimeter's 4 Digit Display mode by pressing the blue Shift button and then the Uprange (4) button. Check and record the reading.

q. (Step #15.) Select the 3468A/B's 3 Digit Display mode by pressing the blue Shift button and then the AUTO/MAN (3) button. Check and record the reading.

r. (Step #16.) Select the 3468A/B's 5 Digit Display mode by pressing the blue Shift button and then the Downrange (5) button.

s. (Step #17, 18, and 19.) Set the 3468A/B to the 30V Range. Check the multimeter's 1/10, 1/3, and full scale accuracy by setting the DC Volts Standard for accurate outputs of +3V, +10V, and +30V, respectively. Check and record the readings. Leave the +30V connected to the 3468A/B.

t. (Step #20.) With +30V applied to the 3468A/B, turn Autozero off by pressing the blue Shift button and then the INT/TRIG (AUTO/ZERO) button. Check and record the reading.

u. (Step #21.) Turn Autozero on by pressing the blue Shift button and then the INT/TRIG (AUTO/ZERO) button.

v. (Step #22.) Set the 3468A/B to the 300V Range. Check the full scale accuracy by setting the DC Volts Standard for an accurate output of +300V. Check and record the readings.

w. (Step #23.) Turn the DC Volts Standard's output off. Disconnect the DC Volts Standard and Digital Voltmeter from the 3468A/B.

x. (Step #24.) The DC Common Mode Rejection Test is next. Do the following:

1. Set the 3468A/B to the .3V Range.

2. Connect a 1K ohm resistor (-hp- Part No. 0698-1021) between the 3468A/B's HI and LO INPUT Terminals.

3. Note the 3468A/B's reading.

4. With the DC Volts Standard's output off, connect the standard to the 3468A/B as shown in Figure 4-3.

5. Set the DC Volts Standard for an output of 400V and then turn its output on. Check and make sure the 3468A/B's reading is within .040mV of the reading noted in step 3.

y. Turn the DC Volts Standard's output off and then disconnect it from the 3468A/B. This completes the DC Volts Test. If any test fails, try calibrating the instrument (go to paragraph 4-86). If the test still fails, go to Section VII of this manual for troubleshooting.

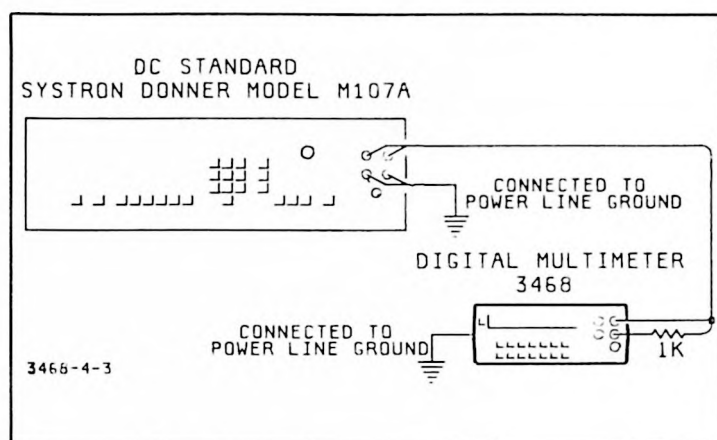


Figure 4-3. DC Common Mode Rejection Test

#### 4-54. DC Current Test

4-55. The DC Current Test limits are printed on the DC Current Test Card and in Table 4-4. Each step on the test card also corresponds to a step in the procedure with each step number shown in parenthesis in the procedure.

4-56. Unless otherwise noted, all test signals are applied to the 3468A/B's A (Amps) and LO INPUT Terminals.

4-57. **Equipment Required.** The following is the required test equipment for the DC Current Test.

Digital Voltmeter (-hp- Model 3456A)  
DC Volts Standard (Systron Donner Model M107)  
AC-DC Current Calibrator (Valhalla Model 2500)

4-58. **Test Procedure.** Make sure the DC Volts Performance Test has been completed, before doing the DC Current Test. Also make sure the 3468A/B has been warmed up for at least one hour, then do the following:

a. (Step #1.) Reset the 3468A/B by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

b. (Step #2.) Set the 3468A/B to the DC Current Function and short the multimeter's A (Amps) Terminal to the LO INPUT Terminal.

c. Record the displayed reading on the Test Card and make sure the reading is within the limits shown on the Test Card and Table 4-4.

d. (Step #3.) Remove the short from the A and LO INPUT Terminals.

e. Set the DC Volts Standard for a +1V output.

f. Set the Digital Voltmeter to the DC Volts Function, 1V Range, and 6 Digit Display mode.

g. Set the AC-DC Current Calibrator to the 1A Range.

h. Connect the DC Volts Standard and Digital Voltmeter to the AC-DC Current Calibrator as shown in Figure 4-4.

i. Connect the AC-DC Current Calibrator to the 3468A/B as shown in Figure 4-3.

j. Make sure the reading on the Digital Voltmeter is exactly +1V. Readjust the DC Volts Standard, if necessary.

k. Check and record the reading on the 3468A/B.

l. Remove the DC Volts Standard and Digital Voltmeter from the AC-DC Current Calibrator. Remove the current calibrator from the 3468A/B. This completes the DC Current Test. If any test fails, try calibrating the instrument (go to paragraph 4-90). If the test still fails, go to this manual's Section VII for troubleshooting.

#### 4-59. AC Volts Test

4-60. The AC Volts Test limits are printed on the AC Volts Test Card and in Table 4-5. Each step on the test card also corresponds to a step in the procedure with each step number shown in parenthesis in the procedure.

4-61. All test signals are applied to the 3468A/B's HI and LO INPUT Terminals.

4-62. **Equipment Required.** The required test equipment for the AC Volts Test is the AC Calibrator (Fluke Model 5200A, 5215A Option 05).

4-63. **Test Procedure.** Make sure the DC Volts Performance Tests have been completed before doing the AC

Table 4-4. DC Current Test Limits

3468A/B Input	3468A/B Range	3468A/B Setup	90 Day Limits		1 Year Limits	
			high	low	high	low
Short +1A	3A 3A	DCI	+0.0006A +1.00146A	-0.00006A +0.99854A	+0.00006A +1.00176A	-0.00006A +0.99824A



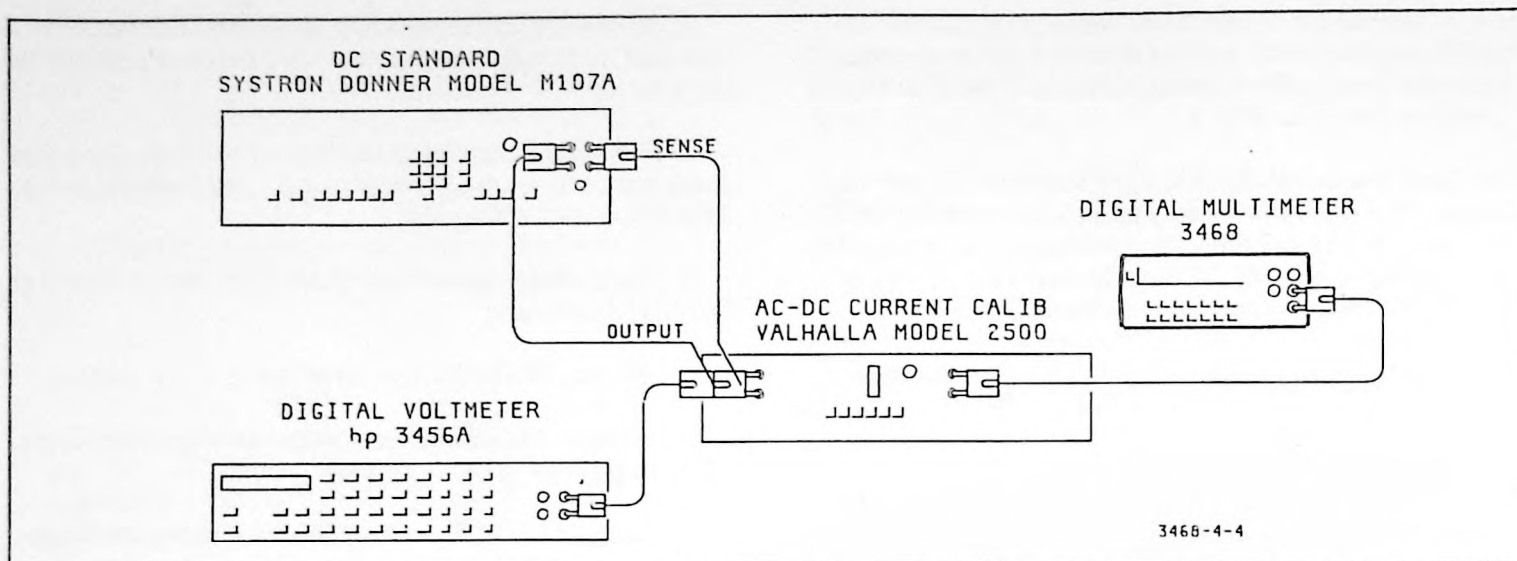


Figure 4-4. DC Current Accuracy Test

Volts Test. Also make sure the 3468A/B has been warmed up for at least one hour, then do the following:

a. (Step #1.) Reset the 3468A/B by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

b. (Step #2.) Set the 3468A/B to the AC Volts Function.

c. Set the AC Calibrator for a .028V at 20KHz output. Connect the output of the calibrator to the INPUT Terminals of the 3468A/B.

d. (Step #3 and 4.) Set the 3468A/B to the .3V Range. Check the 1/10 and full scale reading of the range by applying .028V at 20KHz and .28V at 20KHz, respectively.

Check the readings and make sure they are within the specified limits shown in Table 4-5 and the AC Volts Performance Test Card. Record the readings.

e. (Step #5, 6, and 7.) Set the 3468A/B to the 3V Range. Check the 1/10, 1/2, and full scale accuracy of the range by applying 0.28V at 20KHz, 1.5V at 20KHz, and 2.8V at 20KHz, respectively. Check and record the readings.

f. (Step #8 and 9.) Set the 3468A/B to the 30V Range. Check the 1/10 and full scale accuracy of the range by applying 2.8V at 20KHz and 28V at 20KHz, respectively. Check and record the readings.

g. (Step #10 and 11.) Set the 3468A/B to the 300V Range. Check the 1/10 and full scale accuracy of the range by applying 28V at 20KHz and 280V at 20KHz, respectively. Check and record the readings.

h. (Step #12, 13, 14, and 15.) Check the full scale accuracy of the .3V, 3V, 30V, and 300V Range by applying .28V at 50KHz, 2.8V at 50KHz, 28V at 50KHz, and 280V at 50KHz, respectively. Check and record the readings.

i. (Step #16.) Set the 3468A/B to the .3V Range. Check the full scale accuracy of the range by applying .28V at 100KHz. Check and record the reading.

j. (Step #17 and 18.) Set the 3468A/B to the 3V Range. Check the 1/10 and full scale accuracy of the range by applying .28V at 100KHz and 2.8V at 100KHz, respectively. Check and record the readings.

k. (Step #19 and 20.) Set the 3468A/B to the 30V Range. Check the 1/2 and full scale accuracy of the range by applying 15V at 100KHz and 28V at 100KHz, respectively. Check and record the readings.

Table 4-5. AC Volts Test Limits

3468A/B Input	3468A/B Range	3468A/B Set Up	1 Year Limits	
			high	low
.028V, 20KHz	.3V	ACV	.028244V	.027756V
0.28V, 20KHz	.3V		.280975V	.279025V
0.28V, 20KHz	3V		0.28175V	0.27825V
1.5V, 20KHz	3V		1.50492V	1.49508V
2.8V, 20KHz	3V		2.80830V	2.79170V
2.8V, 20KHz	30V		02.8175V	02.7825V
28V, 20KHz	30V		28.0830V	27.7170V
28V, 20KHz	300V		028.194V	027.806V
280V, 20KHz	300V		281.026V	278.974V
0.28V, 50KHz	300mV		.281815V	.278185V
2.8V, 50KHz	3V		2.81328V	2.78672V
28V, 50KHz	30V		28.1328V	27.8672V
280V, 50KHz	300V		281.720V	278.280V
0.28V, 100KHz	300mV		.285754V	.274246V
0.28V, 100KHz	3V		0.29119V	0.26881V
2.8V, 100KHz	3V		2.83765V	2.76235V
15V, 100KHz	30V		15.2400V	14.7600V
28V, 100KHz	30V		28.3765V	27.6235V
280V, 100KHz	300V		284.353V	275.647V
25V, 300KHz	30V		27.8970V	22.1030V
2.8V, 50Hz	3V		2.81391V	2.78609V
2.8V, 20Hz	3V		2.83294V	2.76706V

l. (Step #21.) Set the 3468A/B to the 300V Range. Check the full scale accuracy of the range by applying 280V at 100KHz. Check and record the reading.

m. (Step #22.) Set the 3468A/B to the 30V Range. Check the full scale accuracy of the range by applying 25V at 300KHz. Check and record the reading.

n. (Step #23 and 24.) Set the 3468A/B to the 3V Range. Check the full scale accuracy of the range by applying 2.8V at 50Hz and then 2.8V at 20Hz.

o. Disconnect the AC Calibrator from the 3468A/B. This completes the AC Volts Test. If any test fails, try calibrating the instrument (go to paragraph 4-94). If the test still fails, go to this manual's Section VII for troubleshooting.

#### 4-64. AC Current Test

4-65. The AC Current Test limits are printed on the AC Current Test Card and in Table 4-6. Each step on the test card also corresponds to a step in the procedure with each step number shown in parenthesis in the procedure.

**Table 4-6. AC Current Test Limits**

3468A/B Input	3468A/B Range	3468A/B Set Up	1 Year Limits	
			high	low
.03A,5KHz	.3A	ACI	.030463A	.029537A
0.1A 5KHz	.3A		.101163A	.098837A
1A,5KHz	1A		1.01863A	0.98137A

4-66. All test signals are applied to the 3468A/B's A (Amps) and LO INPUT Terminals.

**4-67. Equipment Required.** The following is the required test equipment for the AC Current Test.

AC Calibrator (Fluke Model 5200A Option 05).  
AC Calibrator (Valhalla Model 2500).

**4-68. Test Procedure.** Make sure the AC Volts Performance Test has been completed, before doing the AC Current Test. Also make sure the 3468A/B has been warmed up for at least one hour, then do the following:

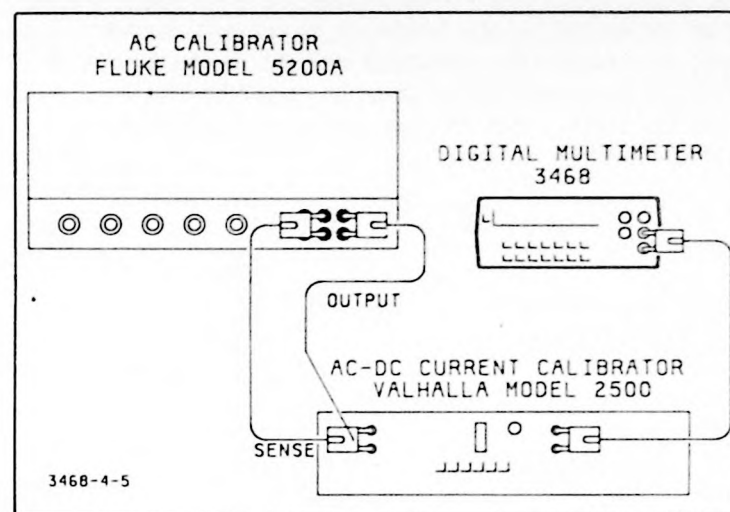
a. (Step #1.) Reset the 3468A/B by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

b. (Step #2.) Set the 3468A/B to the AC Current Function and the .3A Range.

c. (Step #3.) Set the AC Calibrator for a 1V at 5KHz output.

d. Set the AC-DC Current Calibrator to 30mA.

e. Connect the AC Calibrator to the AC-DC Current Calibrator as shown in Figure 4-5.



**Figure 4-5. AC Current Accuracy Test**

f. Connect the 3468A/B to the AC-DC Current Calibrator as shown in Figure 4-5.

g. Check and record the 3468A/B's reading.

h. (Step #4.) Set the AC-DC Current Calibrator to the 100mA Range. Check and record the 3468A/B's reading.

i. (Step #5.) Set the 3468A/B and the AC-DC Current Calibrator to the 1A Range. Check and record the 3468A/B's reading.

j. Remove the AC Calibrator from the AC-DC Current Calibrator. Remove the current calibrator from the 3468A/B. This completes the AC Current Test. If any test fails, try calibrating the instrument (go to paragraph 4-99). If the test still fails, go to this manual's Section VII for troubleshooting.

#### 4-69. Ohms Test

4-70. The Ohms Test should only be performed in the ohms function in which the 3468A/B was last calibrated. If, for example, the 3468A/B was last calibrated in the 4-Wire Ohms Function, perform the Ohms Test in the 4-Wire Ohms Function. If the 3468A/B was last calibrated in the 2-Wire Ohms Function, perform the Ohms Test in the 2-Wire Ohms Function. In addition, the same test connections or leads used to calibrate the 3468A/B in the 2-Wire Ohms Function must also be used when testing the multimeter in that function. This is because the impedance of the test leads is cancelled out when the multimeter is calibrated (in the 2-Wire Ohms Function). A different set of test leads can have different impedances which show up as an ohms test error.

4-71. The Ohms Function of the 3468A/B can be tested using either full scale or 1/3 scale inputs (e.g. 3K ohm or 1K ohm resistors to check the 3K ohm Range). Because



of this, both test limits are given in Table 4-7 and on the Ohms Performance Test Card. The test step numbers (on the Test Card) shown in parenthesis are for the 1/3 scale tests. When testing the 3468A/B, make sure the test leads used to connect the standard resistor to the 3468A/B's INPUT Terminals are as short as possible. This is to prevent the leads from picking up any noise, which could give an invalid reading.

4-72. If the 3468A/B is to be tested in the 2-Wire Ohms Function, all test resistors are applied to the 3468A/B's INPUT Terminals. If the 4-Wire Ohms Function is to be tested, short the INPUT Terminals or connect the test resistors as shown in Figure 4-6 and Figure 4-7, respectively.

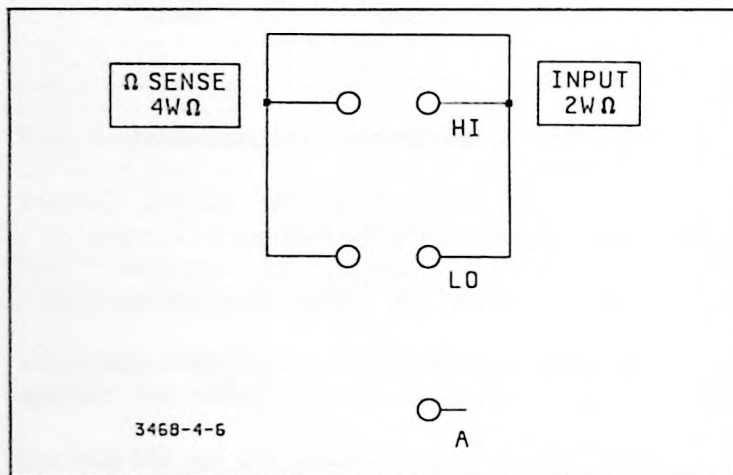


Figure 4-6. 4-Wire Ohms Test Connection

4-73. The Ohms Test limits are printed on the Ohms Test Card and in Table 4-7. Each step on the test card corresponds to a step in the procedure with each step number shown in parenthesis in the procedure.

4-74. **Equipment Required.** The following is the required test equipment for the Ohms Test.

Standard Resistors:

- 100 ohm  $\pm .0005\%$ ; (Guildline Model 9330/100 or 9330A/100)
- 1K ohm  $\pm .0005\%$ ; (Guildline Model 9330/1K or 9330A/1K)
- 10K ohm  $\pm .001\%$ ; (Guildline Model 9330/10K or 9330A/10K)
- 100K ohm  $\pm .001\%$ ; (Guildline Model 9330/100K or 9330A/100K)
- 1M ohm  $\pm .002\%$ ; (Guildline Model 9330/1M)
- 10M ohm  $\pm .01\%$ ; (Guildline Model 9330/10M)

4-75. **Test Procedure.** Make sure the 3468A/B's DC Volts Tests have been done, before doing the Ohms Test. Also make sure the 3468A/B has been warmed up for at least one hour, then do the following:

a. (Step #1.) Reset the 3468A/B by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

b. (Step #2.) Set the 3468A/B to the desired Ohms Function (see paragraph 4-70). If the 2-Wire Ohms Function is to be tested, short the INPUT Terminals. If the 4-Wire Ohms Function is to be tested, short the SENSE Terminals and the INPUT Terminals, as shown in Figure 4-6. Check the reading on the 3468A/B's display and record the reading on the Test Card.

c. (Step #3, 4, 5, 6, and 7.) Set the 3468A/B to the 3K $\Omega$ , 30K $\Omega$ , 300K $\Omega$ , 3M $\Omega$ , and 30M $\Omega$  Range by pressing the Uprange button once for each range. Record and make sure the reading on each range are within the specified limits. If any readings in this step and step b

Table 4-7. Ohms Test Limits

3468A/B Input	3468A/B Range	3468A/B Set Up	24 Hour Limits		90 Day Limits		1 Year Limits	
			high	low	high	low	high	low
Short	300	Ohms	000.004	-000.004	000.004	-000.004	000.005	-000.005
Short	3K		0.00002K	-0.00002K	0.00002K	-0.00002K	0.00002K	-0.00002K
Short	30K		00.0002K	-00.0002K	00.0002K	-00.0002K	00.0002K	-0.00002K
Short	300K		000.002K	-000.002K	000.002K	-000.002K	000.002K	-000.002K
Short	3M		0.00002M	-0.00002M	0.00002M	-0.00002M	0.00002M	-0.00002M
Short	30M		00.0002M	-00.0002M	00.0002M	-00.0002M	00.0002M	-00.0002M
300	300		300.012	299.988	300.041	299.959	300.056	299.944
(100)			100.004	099.996	100.017	099.983	100.022	099.978
3K	3K		3.00014K	2.99986K	3.00035K	2.99965K	3.00050K	2.99950K
(1K)			1.00006K	0.99994K	1.00013K	0.99987K	1.00018K	0.99982K
30K	30K		30.0014K	29.9986K	30.0035K	29.9965K	30.0050K	29.9950K
(10K)			10.0006K	09.9994K	10.0013K	09.9987K	10.0018K	09.9982K
300K	300K		300.014K	299.986K	300.035K	299.965K	300.050K	299.950K
(100K)			100.006K	099.994K	100.013K	099.987K	100.018K	099.982K
3M	3M		3.00017M	2.99983M	3.00035M	2.99965M	3.00050M	2.99950M
(1M)			1.00007M	0.99993M	1.00013M	0.99987M	1.00018M	0.99982M
30M	30M		30.0110M	29.9890M	30.0200M	29.9800M	30.0236M	29.9764M
(10M)			10.0038M	09.9962M	10.0068M	09.9932M	10.0080M	09.9920M

are out of the specified limits, go to the Ohms Calibration Procedure in paragraph 4-103.

d. (step #8.) Remove the short from the 3468A/B's INPUT Terminals and set the multimeter to the 300 $\Omega$  Range.

e. Connect either a 300 $\Omega$  or 100 $\Omega$  Standard Resistor to the INPUT Terminals (refer to paragraph 4-71 to determine the resistor value). If the 3468A/B is to be tested in the 2-Wire Ohms Function, connect the resistor to the INPUT Terminals. If the test is to be done in the 4-Wire Ohms Function, connect the resistor as shown in Figure 4-7.

f. Check and record the reading.

g. (Step #9 through 13.) Check the 3468A/B's 3K $\Omega$ , 30K $\Omega$ , 300K $\Omega$ , 3M $\Omega$ , and 30M $\Omega$  Ranges by connecting the following standard resistors to the multimeter's input: 3K $\Omega$  (or 1K $\Omega$ ), 30K $\Omega$  (or 10K $\Omega$ ), 300K $\Omega$  (or 100K $\Omega$ ), 3M $\Omega$  (or 1M $\Omega$ ), and 30M $\Omega$  (or 10M $\Omega$ ), respectively. Check and record the readings.

h. Remove the Standard Resistors from the 3468A/B. This completes the Ohms Test. If any test fails, try calibrating the instrument (go to paragraph 4-103). If the test still fails, go to this manual's Section VII for troubleshooting.

#### 4-76. COMBINED CALIBRATION AND PERFORMANCE TESTS

##### 4-77. General

4-78. The following paragraphs have the 3468A/B's Combined Calibration Procedures and Performance Tests. The Performance Tests are included in the procedures since they are normally performed after calibration. The procedures are set up in such a way that the Performance Tests can be ignored, if so desired.

4-79. Since the 3468A/B has no internal adjustments, the multimeter is calibrated electronically. A known good calibration source is applied to the 3468A/B's INPUT Terminals which is used to calibrate the multimeter. Ten readings are then taken and the entered value of the calibration source is compared with the average value of the ten readings. A Calibration Constant is then calculated and stored into the calibration RAM. The constant is used to calculate the correct readings.

##### 4-80. Calibrating the 3468A/B

4-81. The 3468A/B is calibrated by first applying a zero input to the instrument (i.e., INPUT terminals shorted) and then applying a full scale input (or in some cases, a 1/3 scale input). When the zero input is applied, the 3468A/B takes a reading and stores the resultant zero constant in its calibration RAM. When the full scale input is applied, the 3468A/B again takes a reading and stores the resultant gain constant into the RAM. This constant has to be within .955 to 1.045 or the 3468A/B will display an error message. The following is an example on how calibration is performed. The 3V Range in the DC Volts function is chosen for the example. It is sug-

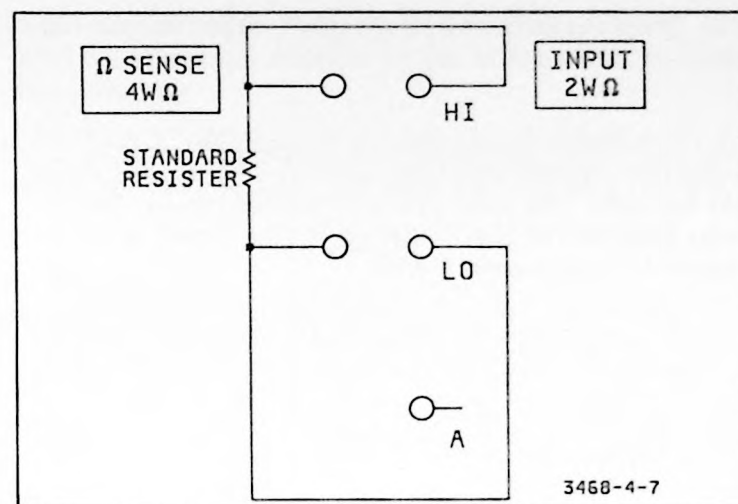


Figure 4-7. 4-Wire Ohms Connections

gested to go through the example before going to the calibration procedures to gain an understanding on how the 3468A/B is calibrated.

- Set the 3468A/B to the DC Volts Function and the 3V Range. Make sure the instrument is not in Autorange.
- Short the instrument's INPUT Terminals (zero input).
- Set the rear panel CAL ENABLE Switch to the calibration enable position (the down position, as shown on the rear panel).

#### NOTE

*The rear panel switches can be externally set without instrument disassembly by doing the following:*

- Bring the rear panel under a light source to locate the switches inside the instrument. Determine which switch you want changed.
- Insert a small blade screwdriver or awl through the appropriate opening on the rear panel.
- Place the screwdriver or awl below or above the switch rocker, dependent on the position of the rocker. Push the rocker up or down.

- Set the multimeter to the Single Trigger mode by pressing the SGL/TRIG button.
- A zero reading, or an approximate zero reading, should now be displayed. In addition to the reading, "C:" is also displayed to the right of the reading (e.g. "+0.00002C:").
- Press the blue Shift button and then the LOCAL (CAL) button.
- The 3468A/B then makes a measurement and decides what type of input is applied to the instrument. Since it is a zero input, the 3468A/B should now display +0.00000? VDC. (The displayed "C:" is replaced by a "?".)



h. Press the SGL/TRIG (Single Trigger) button only once.

i. The 3468A/B will display "+0.00000? CAL" for about five seconds and then "ZERO DONE" for about two seconds. The zero calibration constant for the DC Volts Function in the 3V Range is now stored in the instrument's calibration RAM.

j. Remove the short from the 3468A/B and apply an accurate +3V to the INPUT Terminals. For best accuracy, use a +3V calibration source of which its exact value is known (e.g. +3.00015V, +2.99985V, etc.). This voltage must be within the range of +2.99000V to +3.01000V.

k. Press the blue Shift button and then the LOCAL (CAL) button.

l. The 3468A/B again makes a measurement, and this time decides that the applied input is +3V. The display should now show "+3.00000? VDC".

m. If the exact value of the calibration source is unknown, but the source is accurate enough to calibrate the multimeter, continue with step o.

n. If the exact value of the calibration source is known, the 3468A/B can be calibrated to that value. This is done by setting the display to the known value. The thing to remember is that the display can show no more than  $\pm 1000$  counts of the absolute value. The calibration is performed as follows:

1. After the CAL button is pressed, the 3468A/B will display "+3.00000? VDC". The reading on the display can now be changed using the Uprange and Downrange buttons until the applied value and displayed value agree with each other.

2. If the source is above +3V, press the 3468A/B's Uprange button until the displayed reading agrees with the source. Pressing the button once will increment the reading by one count. To continue increasing the displayed reading, press the button repeatedly. For example, if the source is +3.00015V, press the Uprange button 15 times, until "+3.00015? VDC" is displayed. If the button was pressed too long and the displayed reading is too high, press the Downrange button until the values agree.

3. If the source is below +3V, press the 3468A/B's Downrange button until the displayed reading agrees with the source. This operation is the same as using the Uprange button, except the displayed reading is decreased rather than increased. For example, if the source is +2.99985V, press the Downrange button until "+2.99985? VDC" is displayed.

o. Press the SGL/TRIG button once.

p. The 3468A/B will display "+3.00000? CAL" for about five seconds, as it measures the calibration source and compares it to the number previously displayed (step

l or n). If the calibration source were outside the limits of 2.99000 to 3.01000 volts, the "INV CAL SIG" error message will be displayed (refer to paragraph 4-83c). If the source is within the limits, a "GAIN CONSTANT" is automatically calculated and stored in internal memory. All subsequent dc voltage measurements will be corrected by this gain constant. Consequently, they will be no more accurate than the accuracy of the calibration source itself.

q. The message "GAIN DONE" will be displayed for about two seconds when the calibration process is completed.

r. If there is no more calibration to be performed, set the 3468A/B's CAL ENABLE switch to the up position. The instrument is now ready for use.

## NOTE

*Make sure the CAL ENABLE switch at the rear panel is in the "up" position, before cycling power on the instrument.*

## 4-82. Calibration Messages

4-83. When calibrating the 3468A/B, certain messages may be displayed by the multimeter. The following steps lists the messages and also gives information on what to do if a certain message is displayed.

a. ENABLE CAL - This message shows that the rear panel CAL ENABLE switch is not in the enable position (the switch is in the up position) when attempting to calibrate the multimeter. Make sure the switch is in the correct position, when attempting to calibrate.

b. INV CAL F&R - This message is displayed if the calibration constants cannot be calculated in the present function or range. It is most likely caused if the 3468A/B is set to an invalid range or function.

c. INV CAL SIG - This shows that the 3468A/B cannot calibrate to the applied input signal. This message is displayed if the applied signal causes the 3468A/B to calculate a gain constant which is out of range (.955 to 1.045) or an offset constant greater than 10,000 counts. Make sure the correct signal is applied for the selected function and range.

d. INV CAL ZERO - The 3468A/B displays this message if the zero calibration constant is invalid when attempting to calibrate the gain. Make sure the 3468A/B has been calibrated by a correct zero signal.

e. INV CAL NUM - This message shows that the number in the display is not acceptable for calibration. Make sure the number is within  $\pm 1000$  counts of 300000 (or 100000 for 1/3 scale calibration) and also make sure no zero calibration is attempted with display not at zero, when calibrating over the HP-IL.

f. CAL RAM BAD - This shows that the Calibration RAM did accept data which was written to it, but the data was incorrect. Redo the calibration.

#### 4-84. Calibration Procedures

4-85. Each step in the procedures and the procedures themselves must be done in the order they are given. Each procedure has two parts, Calibration and Performance Test. The performance test part can be ignored, if so desired. Since, after calibration, the 3468A/B will meet its full scale 24 Hour limits, the performance test for full scale (or in some cases 1/3 scale) and zero inputs are not included. This is because the 3468A/B is normally calibrated using full scale (or 1/3 scale) and zero inputs. The Calibration and Performance Test Procedures are separated as follows:

- DC Volts Calibration and Test- paragraph 4-86.
- DC Current Calibration and Test - paragraph 4-90.
- AC Volts Calibration and Test - paragraph 4-94.
- AC Current Calibration and Test - paragraph 4-99.
- Ohms Calibration and Test - paragraph 4-103.

#### 4-86. DC Volts Calibration and Test

4-87. Refer to Table 4-8 for the DC Volts Calibration Signals, Performance Test Signals, and Performance Test Limits. Each step in the table is shown in parenthesis in the procedure. Unless otherwise noted, the calibration and test signals are applied to the 3468A/B's INPUT Terminals.

Table 4-8. DC Volts Calibration and Test

Step#	3468A/B Input	3468A/B Range	3468A/B Set Up	Test Limits	
				high	low
1	Short	.3V	DCV	Cal.	Cal.
2	+300mV	.3V		Cal.	Cal.
3	Short	3V		Cal.	Cal.
4	+3V	3V		Cal.	Cal.
5	+300mV	3V	AZ Off	+30003V	+0.29997V
6	+1V	3V		+1.00006V	+0.99994V
7	-1V	3V		-1.00006V	-0.99994V
8	-3V	3V		-3.00013V	-2.99987V
9	+3V	3V	AZ On,	+3.00016	+2.99984V
10	+3V	3V			
11				+3.0002V	+2.9998V
12	+3V	3V		+3.001V	+2.999V
13	Short	30V	5 Digit	Cal.	Cal.
14	+30V	30V		Cal.	Cal.
15	+3V	30V		+03.0005V	+02.9995V
16	+10V	30V		+10.0008V	+09.9992V
17	+30V	30V	AZ Off	+30.0029V	+29.9971V
18	Short	300V		Cal.	Cal.
19	+300V	300V		Cal.	Cal.

4-88. Equipment Required. The following is the required test equipment for the DC Volts Calibration and Test.

Digital Voltmeter (-hp- Model 3456A)  
DC Volts Standard (Systron Donner Model M107)

4-89. Calibration and Test Procedure. After the 3468A/B has been warmed up for at least one hour, do the following:

- Reset the 3468A/B by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

#### NOTE

*Resetting the 3468A/B automatically places the instrument into the DC Volts Function, Autorange, Internal Trigger, and 5 Digits Displayed Mode.*

- Set the rear panel CAL ENABLE Switch to the calibration enable position (the switch is in the down position, as shown on the rear panel).

- Set the multimeter to the Single Trigger Mode by pressing the SGL/TRIG button.

- (Step #1.) Short the 3468A/B's INPUT Terminals. Set the instrument to the .3V Range (take out of Autorange).

- Press the blue Shift button and then the LOCAL (CAL) button.

- Press the SGL/TRIG (Single Trigger) button only once and then remove the short from the Input Terminals.

- Set the DC Volts Standard for zero volts output.

- (Step #2.) Connect the 3468A/B to the Digital Voltmeter and DC Volts Standard, as shown in Figure 4-2. Use the Digital Voltmeter (DVM) as the standard and the DC Volts Standard as a stable power supply.

- Set the DC Volts Standard's output for +300mV and note the reading on the Digital Voltmeter.

- Press the blue Shift button and then the LOCAL (CAL) button.

- Using the 3468A/B's Uprange and/or Downrange buttons, adjust the reading on the multimeter until it agrees with the reading on the Digital Voltmeter.

- Press the SGL/TRIG (Single Trigger) button once.

- (Step #3 and 4.) Remove the Digital Voltmeter and the DC Volts Standard from the 3468A/B. Short the 3468A/B's INPUT Terminals and set the instrument to the 3V Range.

- Calibrate the 3V Range (applying zero and full scale inputs) by using the procedure in steps e to l. The only exception is that the DC Volts Standard is set for an output (in step i) of +3V instead of +300mV.



o. If no performance checks for the 3V range are to be made, remove the DC Volts Standard and Digital Voltmeter from the 3468A/B. Continue with step q.

p. If the performance checks for the 3V Range are to be made, do the following:

1. Set the 3468A/B to the Internal Trigger Mode by pressing the INT/TRIG button.

2. (Step #5.) Set the DC Volts Standard for a +300mV output.

3. Using the Digital Voltmeter as the standard, check and make sure the 3468A/B reading is within the specified limits shown in Table 4-8.

4. (Step #6.) Set the DC Volts Standard for a +1V output. Check the reading.

5. (Step #7.) Apply -1V to the 3468A/B by reversing the input leads. (Leave the leads in that position for the next step.) Check the reading on the multimeter (per Table 4-8).

6. (Step #8.) Apply -3V to the 3468A/B by setting the DC Volts Standard for a 3V output. Check the reading.

7. (Step #9.) Apply +3V to the 3468A/B by reversing the input leads. Check the reading.

8. With +3V applied to the 3468A/B, turn Autozero off by pressing the blue Shift button and then the INT/TRIG (AUTO/ZERO) button. Check the reading.

9. (Step #10.) Turn Autozero on by pressing the blue Shift button and then the INT/TRIG (AUTO/ZERO) button.

10. (Step #11.) With +3V still applied, select the multimeter's 4 Digit Display mode by pressing the blue Shift button and then the Uprange (4) button. Check the reading.

11. (Step #12.) Select the 3468A/B's 3 Digit Display by pressing the blue Shift button and then the AUTO/MAN (3) button. Check the reading.

12. (Step #13.) Select the 3468A/B's 5 Digit Display by pressing the blue Shift button and then the Downrange (5) button.

13. Remove the DC Volts Standard and Digital Voltmeter from the 3468A/B and set the multimeter back to the Single Trigger Mode (press the SGL/TRIG button).

q. (Step #13 and 14.) Short the 3468A/B's INPUT Terminals. Set the instrument to the 30V Range.

r. Calibrate the 30V Range (applying zero and full scale inputs) by using the procedure in steps e to l. The only exception is that the DC Volts Standard is set for an output (in step i) of +30V instead of +300mV.

s. If no performance checks for the 30V range are to be made, remove the DC Volts Standard and Digital Voltmeter from the 3468A/B. Continue with step u.

t. If the performance checks for the 30V Range are to be made, do the following:

1. Set the 3468A/B to the Internal Trigger Mode by pressing the INT/TRIG button.

2. (Step #15.) Set the DC Volts Standard for a +3V output.

3. Using the Digital Voltmeter as the standard, check and make sure the 3468A/B reading is within the specified limits shown in Table 4-8.

4. (Step #16.) Set the DC Volts Standard for a +10V output. Check the reading on the multimeter.

5. (Step #17.) Set the DC Volts Standard for a +30V output.

6. With +30V applied to the 3468A/B, turn Autozero off by pressing the blue Shift button and then the INT/TRIG (AUTO/ZERO) button. Check and make sure the reading is within 11 counts of the +30V calibration source.

7. (Step #18.) Turn Autozero on by pressing the blue Shift button and then the INT/TRIG (AUTO/ZERO) button.

8. Remove the DC Standard and Digital Voltmeter from the 3468A/B and set the multimeter back to the Single Trigger Mode (press the SGL/TRIG button).

u. (Step #18 and 19.) Short the 3468A/B's INPUT Terminals. Set the instrument to the 300V Range.

v. Calibrate the 300V Range (applying zero and full scale inputs) by using the procedure in steps e to l. The only exception is that the DC Volts Standard is set for an output (in step i) of +300V instead of +300mV.

w. If no DC Common Mode Rejection Test is to be made, turn the output of the DC Volts Standard off and remove it and the Digital Voltmeter from the 3468A/B.

x. If DC Common Mode Rejection Test is to be made, do the following:

1. Set the 3468A/B to the .3V Range.

2. Connect a 1K ohm resistor (-hp- Part No.

0698-1021) between the 3468A/B's HI and LO INPUT Terminals.

3. Note the 3468A/B's reading.

4. With the DC Volts Standard's output off, connect the standard to the 3468A/B as shown in Figure 4-3.

5. Set the DC Volts Standard for 400V output and then turn its output on. Check and make sure the 3468A/B's reading is within .040mV of the reading noted in step 3.

6. Turn the DC Standard's output off and then disconnect it from the 3468A/B. This completes the DC Volts Test (and Calibration). If any test fails, go to Section VII of this manual for troubleshooting.

#### 4-90. DC Current Calibration and Test

4-91. Refer to Table 4-9 for the DC Current Calibration Signals, Performance Test Signals, and Performance Test Limits. Each step in the table is shown in parenthesis in the procedure. All test Signals are applied to the 3468A/B's A (Amps) and LO INPUT Terminals.

**Table 4-9. DC Current Calibration and Test**

Step#	3468A/B Input	3468A/B Range	3468A/B Set Up	Test Limits	
				high	low
1	Open	3A	DCI	Cal.	Cal.
2	+ 1A	3A		Cal.	Cal.

**4-92. Equipment Required.** The following is the required test equipment for the DC Current Calibration and Test.

Digital Voltmeter (-hp- Model 3456A)  
DC Volts Standard (Systron Donner Model M107)  
AC-DC Current Calibrator (Valhalla Model 2500)

**4-93. Calibration and Test Procedure.** Do the following:

a. Reset the 3468A/B by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

b. Make sure the rear panel CAL ENABLE Switch is set to the calibration enable position (the switch is in the down position).

c. (Step #1.) Set the 3468A/B to the DC Current Function and the 3A Range.

d. Set the multimeter to the Single Trigger Mode by pressing the SGL/TRIG button.

e. Make sure no connections are made between the A and LO INPUT Terminals.

f. Press the blue Shift button and then the LOCAL (CAL) button.

g. Press SGL/TRIG button once.

h. Set the DC Volts Standard for a +1V output.

i. Set the Digital Voltmeter to the DC Volts Function, 1V Range, and 6 Digit Display Mode.

j. Set the AC-DC Current Calibrator to the 1A Range.

k. Connect the DC Volts Standard and Digital Voltmeter to the AC-DC Current Calibrator as shown in Figure 4-4.

l. (Step #2.) Calibrate the 3468A/B by doing the procedure in steps f and g.

m. Since the performance checks are the same as the calibration points, the checks are not required. Remove the DC Volts Standard and Digital Voltmeter from the AC-DC Current Calibrator and remove the calibrator from the 3468A/B. This completes the 3468A/B's DC Current Calibration and Test.

#### 4-94. AC Volts Calibration and Test

4-95. The AC Volts Function is calibrated using only one calibration source, 3V at 1KHz. With the 3V ac signal applied, the 3468A/B determines the gain constants by taking a measurement in the 3V Range and 30V Range. The measurement in the 3V Range is a full-scale measurement and the 30V Range is a 1/10 scale measurement. The ranges are automatically selected by the multimeter.

4-96. Refer to Table 4-10 for the AC Volts Calibration Signals, Performance Test Signals, and Performance Test Limits. Each step in the table is shown in parenthesis in the procedure. All test signals are applied to the 3468A/B's INPUT Terminals.

**4-97. Equipment Required.** The required test equipment for the AC Volts Calibration and Test is an AC Calibrator (Fluke Model 5200A/5215A option 05).

**4-98. Calibration and Test Procedure.** Do the following:

a. Reset the 3468A/B by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.

b. Make sure the rear panel CAL ENABLE Switch is set to the calibration enable position (the switch is in the rear position).

c. (Step #1.) Set the 3468A/B to the AC Volts Function and the 3V Range.

d. Set the multimeter to the Single Trigger Mode by pressing the SGL/TRIG button.



e. Set the AC Calibrator for a 3V at 1KHz output and connect it to the 3468A/B's INPUT Terminals.

f. Press the blue Shift button and then the LOCAL (CAL) button.

g. Using the 3468A/B's Uprange and/or Downrange buttons, adjust the reading on the multimeter until it agrees with the output value of the AC Calibrator (if the output value is known).

h. Press the SGL/TRIG button once.

i. If no performance checks are to be made, remove the AC Calibrator from the 3468A/B. AC Volts Calibration is now completed.

j. (Step #2.) If the performance checks are to be made, set the AC Calibrator for a .028V at 20KHz output. Set the 3468A/B to the .3V Range. Check the reading on the multimeter and make sure it is within the specified limits (per Table 4-10).

k. (Step #3.) Do the same as in the previous step by applying .28V at 20KHz to the multimeter.

l. (Step #4, 5, and 6.) Set the 3468A/B to the 3V Range. Check the 1/10, 1/2, and full scale accuracy of the range by applying .28V at 20KHz, 1.5V at 20KHz, and 2.8V at 20KHz, respectively. Check the readings.

m. (Step #7 and 8.) Set the 3468A/B to the 30V Range. Check the 1/10 and full scale accuracy of the range by applying 2.8V at 20KHz and 28V at 20KHz, respectively. Check the readings.

n. (Step #9 and 10.) Set the 3468A/B to the 300V Range. Check the 1/10 and full scale accuracy of the range by applying 28V at 20KHz and 280V at 20KHz, respectively. Check the readings.

o. (Step #11, 12, 13, and 14.) Check the full scale accuracy of the .3V, 3V, 30V, and 300V Range by applying .28V at 50KHz, 2.8V at 50KHz, 28V at 50KHz, and 280V at 50KHz, respectively.

p. (Step #15.) Set the 3468A/B to the .3V Range. Check the full scale accuracy of the range by applying .28V at 100KHz. Check the reading.

q. (Step #16 and 17.) Set the 3468A/B to the 3V Range. Check the 1/10 and full scale accuracy of the range by applying .28V at 100KHz and 2.8V at 100KHz, respectively. Check the readings.

r. (Step #18 and 19.) Set the 3468A/B to the 30V Range. Check the 1/2 and full scale accuracy of the range by applying 15V at 100KHz and 28V at 100KHz, respectively. Check the readings.

s. (Step #20.) Set the 3468A/B to the 300V Range. Check the full scale accuracy of the range by applying 280V at 100KHz. Check the reading.

t. (Step #21.) Set the 3468A/B to the 30V Range. Check the full scale accuracy of the range by applying 25V at 300KHz. Check the reading.

u. (Step #22 and 23.) Set the 3468A/B to the 3V Range. Check the full scale accuracy of the range by applying 2.8V at 50Hz and then 2.8V at 20Hz.

v. Disconnect the AC Calibrator from the 3468A/B. This completes the AC Volts Calibration and Test.

#### 4-99. AC Current Test (Optional)

4-100. Since the DC Current and AC Volts Calibration has been performed, no AC Current Calibration is necessary. If there is any doubt about the accuracy of the AC Current Function, the function can be checked using the Optional AC Current Test Procedures in the following paragraphs. Refer to Table 4-11 for the Performance Test Signals and Performance Test Limits. Each step in the table is shown in parenthesis in the procedure. All test signals are applied to the A (amps) and LO INPUT Terminals.

Table 4-10. AC Volts Calibration and Test

Step#	3468A/B Input	3468A/B Range	3468A/B Set Up	Test Limits	
				high	low
1	3V, 1KHz	3V	ACV	Cal.	Cal.
2	.028V, 20KHz	.3V		.028244V	.027756V
3	0.28V, 20KHz	.3V		.280975V	.279025V
4	0.28V, 20KHz	3V		0.28175V	0.27825V
5	1.5V, 20KHz	3V		1.50492V	1.49508V
6	2.8V, 20KHz	3V		2.80830V	2.79170V
7	2.8V, 20KHz	30V		02.8175V	02.7825V
8	28V, 20KHz	30V		28.0830V	27.7170V
9	28V, 20KHz	300V		028.194V	027.806V
10	280V, 20KHz	300V		281.026V	278.026V
11	0.28V, 50KHz	300mV		.081815V	.278185V
12	2.8V, 50KHz	3V		2.81328V	2.71328V
13	28V, 50KHz	30V		28.1328V	27.8672V
14	280V, 50KHz	300V		281.720V	278.280V
15	0.28V, 100KHz	300mV		.285754V	.274246V
16	0.28V, 100KHz	3V		0.29119V	0.26881V
17	2.8V, 100KHz	3V		2.83765V	2.76235V
18	15V, 100KHz	30V		15.2400V	14.7600V
19	28V, 100KHz	30V		28.3765V	27.6235V
20	280V, 100KHz	300V		284.353V	275.647V
21	25V, 300KHz	30V		27.8970V	22.1030V
22	2.8V, 50Hz	3V		2.81391V	2.78609V
23	2.8V, 20Hz	3V		2.83294V	2.76706V

Table 4-11. AC Current Calibration and Test

Step#	3468A/B Input	3468A/B Range	3468A/B Set Up	Test Limits	
				high	low
1	.03A, 5KHz	.3A	ACI	.030463A	.029537A
2	0.1A, 5KHz	.3A		.101163A	.098837A
3	1A, 5KHz	1A		1.01863A	0.98137A

**4-101. Equipment Required.** The following is the required test equipment for the AC Current Calibration and Test.

AC Calibrator (Fluke Model 5200A Option 05)  
AC-DC Current Calibrator (Valhalla Model 2500)

**4-102. Test Procedure.** Do the following:

- a. Reset the 3468A/B by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.
- b. (Step #1.) Set the 3468A/B to the AC Current Function and the .3A Range.
- c. Set the AC Calibrator for a .3V at 5KHz output.
- d. Set the AC-DC Current Calibrator to the 100mA Range.
- e. Connect the AC Calibrator to the AC-DC Current Calibrator as shown in Figure 4-5.
- f. Check the 3468A/B's reading.
- g. (Step#2.)Set the AC Calibrator for a 1V at 5KHz output. Check the 3468A/B's reading.
- h. (Step #3.) Set the 3468A/B to the 3A Range. Set the AC-DC Current Calibrator to the 1A Range. Check the 3468A/B's reading.
- i. Remove the 3468A/B and the AC Calibrator from the AC-DC Current Calibrator. This completes the AC Current Test.

#### 4-103. Ohms Calibration and Test

4-104. The 3468A/B's Ohms Function can be calibrated in either the 2-Wire or 4-Wire Ohms Function. It cannot be calibrated in both. Make sure the multimeter is calibrated in the function which will be used. If the 3468A/B is to be calibrated in the 2-Wire Ohms Function, connect the Standard Resistors to the 3468A/B's INPUT Terminals. If the 3468A/B is to be calibrated in the 4-Wire Ohms Function, connect the Standard Resistors as shown in Figure 4-7.

4-105. Refer to Table 4-12 for the Ohms Calibration Signals, Performance Test Signals, and Performance Test Limits. Each step in the table is shown in parenthesis in the procedure. All test signals are applied to the INPUT Terminals. The 3468A/B can be calibrated either at full scale or 1/3 scale. Both the full scale and 1/3 input values are given in Table 4-12 and the Performance Test Card. The 1/3 scale input values are given in parenthesis.

**4-106. Equipment Required.** The following is the required test equipment for the Ohms Calibration and Test.

If the 3468A/B is to be calibrated at 1/3 scale, use one of the following recommended standard resistors. If the 3468A/B is to be calibrated at full scale, use three each of the recommended standard resistors to form 3K ohm, 30K ohms, etc.

100 ohm  $\pm .0005\%$ ; (Guildline Model 9330/100 or 9330A/100)  
1K ohm  $\pm .0005\%$ ; (Guildline Model 9330/1K or 9330A/1K)  
10K ohm  $\pm .001\%$ ; (Guildline Model 9330/10K or 9330A/10K)  
100K ohm  $\pm .001\%$ ; (Guildline Model 9330/100K or 9330A/100K)  
1M ohm  $\pm .002\%$ ; (Guildline Model 9330/1M)  
10M ohm  $\pm .01\%$ ; (Guildline Model 9330/10M)

Table 4-12. Ohms Calibration and Test

Step#	3468A/B Input	3468A/B Range	3468A/B Set Up	Test Limits	
				high	low
1	Short	300	Ohms	Cal.	Cal.
2	300	300		Cal.	Cal.
(2)	(100)	300		Cal.	Cal.
3	Short	3K		Cal.	Cal.
4	3K	3K		Cal.	Cal.
(4)	(1K)	3K		Cal.	Cal.
5	Short	30K		Cal.	Cal.
6	30K	30K		Cal.	Cal.
(6)	(10K)	30K		Cal.	Cal.
7	Short	300K		Cal.	Cal.
8	300K	300K		Cal.	Cal.
(8)	(100K)	300K		Cal.	Cal.
9	Short	3M		Cal.	Cal.
10	3M	3M		Cal.	Cal.
(10)	(1M)	3M		Cal.	Cal.
11	Short	30M		Cal.	Cal.
12	30M	30M		Cal.	Cal.
(12)	(10M)	30M		Cal.	Cal.

**4-107. Calibration and Test Procedure.** Do the following:

- a. Reset the 3468A/B by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button.
- b. Make sure the rear panel CAL ENABLE Switch is set to the calibration enable position (the switch is in the down position).
- c. (Step #1.) Set the 3468A/B to the Ohms Function and the 300 $\Omega$  Range.
- d. Set the multimeter to the Single Trigger Mode by pressing the SGL/TRIG button.
- e. Short the 3468A/B's INPUT Terminals. If the 4-Wire Ohms Function is to be calibrated, short the terminals as shown in Figure 4-6.



f. Press the blue Shift button and then the LOCAL (CAL) button.

g. Press the SGL/TRIG button once.

h. (Step #2.) Connect the 300 $\Omega$  or 100 $\Omega$  Standard Resistor to the 3468A/B's INPUT Terminal. If the 4-Wire Ohms Function is to be calibrated, connect the resistor as shown in Figure 4-7.

i. Press the blue Shift button and then the LOCAL (CAL) button.

j. Press the SGL/TRIG button once.

k. (Step #3 and 4.) Set the 3468A/B to the 3K $\Omega$  Range and calibrate the range using zero and full scale (or 1/3 scale) inputs. Use the same procedures in steps d through i, except use a 3K $\Omega$  (or 1K $\Omega$ ) resistor instead of a 300 $\Omega$  (or 100 $\Omega$ ) resistor.

l. (Step #5 and 6.) Set the 3468A/B to the 30K $\Omega$  Range and calibrate the range using zero and full scale (or 1/3 scale) inputs. Use the same procedures in steps d through i, except use a 30K $\Omega$  (or 10K $\Omega$ ) resistor instead of a 300 $\Omega$  (or 100 $\Omega$ ) resistor.

m. (Step #7 and 8.) Set the 3468A/B to the 300K $\Omega$  Range and calibrate the range using zero and full scale (or 1/3 scale) inputs. Use the same procedures in steps d through i, except use a 300K $\Omega$  (or 100K $\Omega$ ) resistor instead of a 300 $\Omega$  (or 100 $\Omega$ ) resistor.

n. (Step #9 and 10.) Set the 3468A/B to the 3M $\Omega$  Range and calibrate the range using zero and full scale (or 1/3 scale) inputs. Use the same procedures in steps d through i, except use a 3M $\Omega$  (or 1M $\Omega$ ) resistor instead of a 300 $\Omega$  (or 100 $\Omega$ ) resistor.

o. (Step #11 and 12.) Set the 3468A/B to the 30M $\Omega$  Range and calibrate the range using zero and full scale (or 1/3 scale) inputs. Use the same procedures in steps d through i, except use a 30M $\Omega$  (or 10M $\Omega$ ) resistor instead of a 300 $\Omega$  (or 100 $\Omega$ ) resistor.

p. Since the points checked in the Performance Test are the same points that were calibrated, no Performance Test is required. Set the read panel CAL ENABLE switch to the up position. This completes the Ohms Calibration and Test.

#### 4-108. REMOTE CALIBRATION

##### 4-109. General

4-110. The 3468A/B can be remotely calibrated using the HP-IL (Hewlett-Packard Interface Loop). In remote calibration, a computer is used to set-up the 3468A/B to the required range, function, and calibration mode instead of doing it from the instrument's front panel.

4-111. Remote calibration uses the same test equipment, including hook up to the 3468A/B, as is used in local calibration. In addition, both remote and local calibration procedures are basically the same in that zero scale and full or 1/3 scale calibration signals are used. It is therefore helpful to know how to calibrate 3468A/B locally. Read the calibration procedures in paragraphs 4-80 to 4-107 before attempting to calibrate remotely.

4-112. The following paragraph has an example on how to remotely calibrate the 3468A/B. In the example, the 3468A/B is calibrated on the 3V Range by remotely sending the appropriate program codes. Then the value of the calibration signal is remotely sent to the 3468A/B's display. Once this is done, the program code to calibrate the instrument is sent. The example shows how to send the program codes using a Model HP-85A computer and an -hp- Model 41CV Handheld Programmable Calculator. It is assumed that you know how to program the 3468A/B using the 85A or 41CV. For information on programming the 3468A/B, refer to the 3468A/B Operator's Manual or Section III of this manual.

##### 4-113. Remote Calibration Example

4-114. Connect the 3468A/B to the HP-IL and make sure it is the first instrument in the loop after the HP-IL controller (i.e., 85A or 41CV). Then turn the controller off and on. This insures that the 3468A/B HP-IL address is "1".

4-115. With the 3468A/B turned on, set the CAL ENABLE switch (switch 8) on the instrument's rear panel to down. A "C" should now appear on the right end of the numbers in the 3468A/B's display indicating that calibration is enabled. Calibrate the instrument on the 3V Range in the DC Volts Function by doing the following steps. Each step is separated into two sections with the first section showing how to calibrate using the 85A and the other using the 41CV. The 3468A/B is calibrated by applying zero volts and 3V or 1V calibration signals. Do the following:

a. The 3468A/B is set to Remote and Listen and then program codes "F1R2N5Z1T1" are sent to the instrument. This sets the 3468A/B to the DC Volts Function (F1), 3V Range (R2), 5 1/2 Digit Displayed (N5), Autozero On (Z1), and Internal Trigger (T1).

1. Model 85A.

OUTPUT 901 ;"F1R2N5Z1T1"

The "OUTPUT 901" statement sets the 3468A/B to Remote and Listen, and "F1R2N5Z1T1" are the program codes sent to the instrument.

## 2. Model 41CV.

## Step#      Action

1. Press XEQ button
2. Press ALPHA button
3. Enter "REMOTE" from keyboard
4. Press ALPHA button
5. Press ALPHA BUTTON
6. Enter "F1R2N6Z1T1" from keyboard
7. Press ALPHA button
8. Press XEQ button
9. Press ALPHA button
10. Enter "OUTA" from keyboard
11. Press ALPHA button

Steps 1 through 4 set the 3468A/B to Remote and Listen. Steps 5 through 7 enter program codes "F1R2N6Z1T1" into the ALPHA register. Steps 8 through 11 output the ALPHA register which sends the program codes to the 3468A/B.

b. After the 3468A/B is set up to the desired function and range, apply the zero volts calibration signal to the instrument. This is done by shorting the HI and LO INPUT Terminals. Once this is performed, the value in the 3468A/B display has to be set to the value of the calibration signal (i.e., 0V). This is done by sending program codes "D2 + 000000". Code "D2" enables the display to receive "000000". Since the 3468A/B is calibrated in the 5 1/2 Digit Mode, make sure that six zeroes (i.e., "000000") are sent instead of just one zero. Also, the "+" between D2 and 000000 needs to be there for the display to accept the numbers correctly.

## 1. Model 85A.

OUTPUT 901 ; "D2 + 000000"

## 2. Model 41C.

## Step#      Action

1. Press ALPHA button
2. Enter "D2 + 000000" from keyboard
3. Press ALPHA button
4. Press XEQ button
5. Press ALPHA button
6. Enter "OUTA" from keyboard
7. Press ALPHA button

Steps 1 through 3 enter program codes "D2 + 000000" into the ALPHA register and steps 4 through 7 output the ALPHA register which sends the codes to the 3468A/B.

c. The 3468A/B is now calibrated by sending program code "C" to the instrument. The instrument will then display "CAL", while it is calculating the zero offset calibration constant. When finished, "ZERO DONE"

will be displayed for about two seconds. Zero calibration is then completed.

## 1. Model 85A.

OUTPUT 901 ; "C"

## 2. Model 41CV.

## Step#      Action

1. Press ALPHA button
2. Enter "C" from keyboard
3. Press ALPHA button
4. Press XEQ button
5. Press ALPHA button
6. Enter "OUTA" from keyboard
7. Press ALPHA button

Steps 1 through 3 enter program code "C" into the ALPHA register and steps 4 through 7 output the ALPHA register which sends the code to the 3468A/B.

d. After zero calibration is completed, apply either a full scale (3V) or 1/3 scale (1V) calibration signal to the 3468A/B's INPUT Terminals. Then set the display to the applied value. Since in this example the applied value is 2.99998V, send program codes "D2 + 2.99998" to the 3468.

## 1. Model 85A.

OUTPUT 901 ; "D2 + 2.99998"

## 2. Model 41CV.

## Step#      Action

1. Press ALPHA button
2. Enter "D2 + 2.99998" from keyboard
3. Press ALPHA button
4. Press XEQ button
5. Press ALPHA button
6. Enter "OUTA" from keyboard
7. Press ALPHA button

Steps 1 through 3 enter program codes "D2 + 2.99998" into the ALPHA register and steps 4 through 7 output the ALPHA register which sends the codes to the 3468A/B.

e. The 3468A/B is now calibrated by sending program code "C" to the instrument. The instrument will then display "CAL", while it is calculating the 3V gain calibration constant. When finished, "GAIN DONE" will be displayed for about two seconds. The gain calibration is then completed.

## 1. Model 85A.

OUTPUT 901 ; "C"



## 2. Model 41CV.

Step#	Action
1.	Press ALPHA button
2.	Enter "C" from keyboard
3.	Press ALPHA button
4.	Press XEQ button
5.	Press ALPHA button
6.	Enter "OUTA" from keyboard
7.	Press ALPHA button

Steps 1 through 3 enter program code "C" into the ALPHA register and steps 4 through 7 output the ALPHA register which sends the code to the 3468A/B.

f. The 3V Range in the DC Volts Function is now calibrated. Calibration of the rest of the ranges and functions is done the same way by calibrating with zero and

full or 1/3 scale inputs. When calibrating at full or 1/3 scale, make sure the display gets the correct information. For example, to calibrate the gain by applying 1V, send program codes "D2+1.00000" to the 3468A/B. The decimal point included in the number sent to the 3468A/B (i.e., +1.00000, +3.00000. etc) is not necessary. It is only included to show the value of the calibration voltage to which the 3468A/B is calibrated.

**4-116. Remote Calibration Exceptions**

a. No calibration is required for the AC Current Function if the AC Volts and DC Current Functions are calibrated. If AC Current calibration is performed, it can only be done at full scale (.3A) on the .3A Range.

b. Full scale or 1/3 scale calibrations can be performed in all functions except the AC Volts Function (and AC Current, see previous paragraph). The AC Volts Function is calibrated only at full scale on only the 3V Range.

# DC VOLTS PERFORMANCE TEST CARD

## 24 HOUR LIMITS

Hewlett-Packard Model 3468A/B  
Digital Multimeter

Test Performed By \_\_\_\_\_  
Date \_\_\_\_\_

Serial Number \_\_\_\_\_

Reference Temperature \_\_\_\_\_

### DC Volts Test

Step#	Input to 3468A/B	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET					
2	Short	.3V Range	+ .000004V	_____	- .000004V	_____	_____
3	Short	3V Range	+ 0.00002V	_____	- 0.00002V	_____	_____
4	Short	30V Range	+ 00.0003V	_____	- 00.0003V	_____	_____
5	Short	300V Range	+ 000.002V	_____	- 000.002V	_____	_____
6	+ 300mV	.3V Range	+ .300019V	_____	+ .299981V	_____	_____
7	+ 300mV	3V Range	+ 0.30003V	_____	+ 0.29997V	_____	_____
8	+ 1V	3V Range	+ 1.00006V	_____	+ 0.99994V	_____	_____
9	- 1V	3V Range	- 1.00006V	_____	- 0.99994V	_____	_____
10	- 3V	3V Range	- 3.00013V	_____	- 2.99987V	_____	_____
11	+ 3V	3V Range	+ 3.00013V	_____	+ 2.99987V	_____	_____
12	+ 3V	Autozero Off	+ 3.00016V	_____	+ 2.99984V	_____	_____
13		Autozero On					
14	+ 3V	4 Digit Disp	+ 3.0002V	_____	+ 2.9998V	_____	_____
15	+ 3V	3 Digit Disp	+ 3.001V	_____	+ 2.999V	_____	_____
16		5 Digit Disp					
17	+ 3V	30V Range	+ 03.0005V	_____	+ 02.9995V	_____	_____
18	+ 10V	30V Range	+ 10.0008V	_____	+ 09.9992V	_____	_____
19	+ 30V	30V Range	+ 30.0018V	_____	+ 29.9982V	_____	_____
20	+ 30V	Autozero Off	+ 30.0029V	_____	+ 29.9971V	_____	_____
21		Autozero On					
22	+ 300V	300V Range	+ 300.019V	_____	+ 299.981V	_____	_____
23	Open	.3V Range					
24	See Below	CMR Test					

### CMR Test

1. Connect a 1K ohm resistor between the HI and LO INPUT Terminals of the 3468A/B.
2. Note the 3468A/B's reading.
3. Apply 400V dc between the 3468A/B's HI INPUT and the Power Line Ground.
4. The 3468A/B should remain within .040mV of the reading in step 2.



# DC VOLTS PERFORMANCE TEST CARD

## 90 DAY LIMITS

Hewlett-Packard Model 3468A/B  
Digital Multimeter

Test Performed By \_\_\_\_\_  
Date \_\_\_\_\_

Serial Number \_\_\_\_\_

Reference Temperature \_\_\_\_\_

### DC Volts Test

Step#	Input to 3468A/B	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET				—	—
2	Short	.3V Range	+ .000005V	_____	- .000005V	—	—
3	Short	3V Range	+ 0.00002V	_____	- 0.00002V	—	—
4	Short	30V Range	+ 00.0003V	_____	- 00.0003V	—	—
5	Short	300V Range	+ 000.002V	_____	- 000.002V	—	—
6	+ 300mV	.3V Range	+ .300032V	_____	+ .299968V	—	—
7	+ 300mV	3V Range	+ 0.30004V	_____	+ 0.29996V	—	—
8	+ 1V	3V Range	+ 1.00009V	_____	+ 0.99991V	—	—
9	- 1V	3V Range	- 1.00009V	_____	- 0.99991V	—	—
10	- 3V	3V Range	- 3.00023V	_____	- 2.99977V	—	—
11	+ 3V	3V Range	+ 3.00023V	_____	+ 2.99977V	—	—
12	+ 3V	Autozero Off	+ 3.00026V	_____	+ 2.99974V	—	—
13		Autozero On					
14	+ 3V	4 Digit Disp	+ 3.0003V	_____	+ 2.9997V	—	—
15	+ 3V	3 Digit Disp	+ 3.001V	_____	+ 2.999V	—	—
16		5 Digit Disp					
17	+ 3V	30V Range	+ 03.0006V	_____	+ 02.9994V	—	—
18	+ 10V	30V Range	+ 10.0012V	_____	+ 09.9988V	—	—
19	+ 30V	30V Range	+ 30.0030V	_____	+ 29.9970V	—	—
20	+ 30V	Autozero Off	+ 30.0041V	_____	+ 29.9959V	—	—
21		Autozero On					
22	+ 300V	300V Range	+ 300.029V	_____	+ 299.971V	—	—
23	Open	.3V Range				—	—
24	See Below	CMR Test				—	—

### CMR Test

1. Connect a 1K Ohm resistor between the HI and LO INPUT Terminals of the 3468A/B.
2. Note the 3468A/B's reading.
3. Apply 400V dc between the 3468A/B's chassis (rear panel) and HI INPUT Terminal.
4. The 3468A/B should remain within .040mV of the reading in step 2.

# DC VOLTS PERFORMANCE TEST CARD

## 1 YEAR LIMITS

Hewlett-Packard Model 3468A/B  
Digital Multimeter

Test Performed By \_\_\_\_\_

Date \_\_\_\_\_

Serial Number \_\_\_\_\_

Reference Temperature \_\_\_\_\_

### DC Volts Test

Step#	Input to 3468A/B	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET				—	—
2	Short	.3V Range	+ .000005V	—	— .000005V	—	—
3	Short	3V Range	+ 0.00002V	—	— 0.00002V	—	—
4	Short	30V Range	+ 00.0003V	—	— 00.0003V	—	—
5	Short	300V Range	+ 000.002V	—	— 000.002V	—	—
6	+ 300mV	.3V Range	+ .300065V	—	+ .299935V	—	—
7	+ 300mV	3V Range	+ 0.30007V	—	+ 0.29993V	—	—
8	+ 1V	3V Range	+ 1.00020V	—	+ 0.99980V	—	—
9	— 1V	3V Range	— 1.00020V	—	— 0.99980V	—	—
10	— 3V	3V Range	— 3.00056V	—	— 2.99944V	—	—
11	+ 3V	3V Range	+ 3.0056V	—	+ 2.99944V	—	—
12	+ 3V	Autozero Off	+ 3.00059V	—	+ 2.99941V	—	—
13		Autozero On					
14	+ 3V	4 Digit Disp	+ 3.0006V	—	+ 2.9994V	—	—
15	+ 3V	3 Digit Disp	+ 3.002V	—	+ 2.998V	—	—
16		5 Digit Disp					
17	+ 3V	30V Range	+ 03.0009V	—	+ 02.9991V	—	—
18	+ 10V	30V Range	+ 10.0023V	—	+ 09.9977V	—	—
19	+ 30V	30V Range	+ 30.0063V	—	+ 29.9937V	—	—
20	+ 30V	Autozero Off	+ 30.0074V	—	+ 29.9926V	—	—
21		Autozero On					
22	+ 300V	300V Range	+ 300.062V	—	+ 299.938V	—	—
23	Open	.3V Range				—	—
24	See Below	CMR Test				—	—

### CMR Test

1. Connect a 1K ohm resistor between the HI and LO INPUT Terminals of the 3468A/B.
2. Note the 3468A/B reading.
3. Apply 400V dc between the 3468A/B's HI INPUT and the Power Line Ground.
4. The 3468A/B should remain within .040mV of the reading in step 2.



## DC CURRENT PERFORMANCE TEST CARD

### 90 DAY LIMITS

Hewlett-Packard Model 3468A/B  
Digital Multimeter

Test Performed By \_\_\_\_\_  
Date \_\_\_\_\_

Serial Number \_\_\_\_\_

Reference Temperature \_\_\_\_\_

#### DC Current Test

Step#	Input to 3468A/B	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET					
2	Open	DCI Function	+ 0.00006A		- 0.00006A		
3	+ 1A	3A Range	+ 1.00146A		+ 0.99854A		

## DC CURRENT PERFORMANCE TEST CARD

### 1 YEAR LIMITS

Hewlett-Packard Model 3468A/B  
Digital Multimeter

Test Performed By \_\_\_\_\_  
Date \_\_\_\_\_

Serial Number \_\_\_\_\_

Reference Temperature \_\_\_\_\_

#### DC Current Test

Step#	Input to 3468A/B	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET					
2	Open	DCI Function	+ 0.00006A		- 0.00006A		
3	+ 1A	3A Range	+ 1.00176A		+ 0.99824A		

# AC VOLTS PERFORMANCE TEST CARD

## 1 YEAR LIMITS

Hewlett-Packard Model 3468A/B  
Digital Multimeter

Test Performed By \_\_\_\_\_

Date \_\_\_\_\_

Serial Number \_\_\_\_\_

Reference Temperature \_\_\_\_\_

### AC Volts Test

Step#	Input to 3468A/B	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET				—	—
2	Open	ACV Function				—	—
3	.028V, 20KHz	.3V Range	.028244V	_____	.027756V	—	—
4	0.28V, 20KHz	.3V Range	.280975V	_____	.279025V	—	—
5	0.28V, 20KHz	3V Range	0.28175V	_____	0.27825V	—	—
6	1.5V, 20KHz	3V Range	1.50492V	_____	1.49508V	—	—
7	2.8V, 20KHz	3V Range	2.80830V	_____	2.79170V	—	—
8	2.8V, 20KHz	30V Range	02.8175V	_____	02.7825V	—	—
9	28V, 20KHz	30V Range	28.0830V	_____	27.710 V	—	—
10	28V, 20KHz	300V Range	028.194V	_____	027.806V	—	—
11	280V, 20KHz	300V Range	281.026V	_____	278.974V	—	—
12	0.28V, 50KHz	.3V Range	.281815V	_____	.278185V	—	—
13	2.8V, 50KHz	3V Range	2.81328V	_____	2.78672V	—	—
14	28V, 50KHz	30V Range	28.1328V	_____	27.8672V	—	—
15	280V, 50KHz	300V Range	281.720V	_____	278.280V	—	—
16	0.28V, 100KHz	.3V Range	.285754V	_____	.274246V	—	—
17	0.28V, 100KHz	3V Range	0.29119V	_____	0.26881V	—	—
18	2.8V, 100KHz	3V Range	2.83765V	_____	2.76235V	—	—
19	15V, 100KHz	30V Range	15.2400V	_____	14.7600V	—	—
20	28V, 100KHz	30V Range	28.3765V	_____	27.6235V	—	—
21	280V, 100KHz	300V Range	284.353V	_____	275.647V	—	—
22	25V, 300KHz	30V Range	27.8970V	_____	22.1030V	—	—
23	2.8V, 50Hz	3V Range	2.81391V	_____	2.78609V	—	—
24	2.8V, 20Hz	3V Range	2.83294V	_____	2.76706V	—	—



## AC CURRENT PERFORMANCE TEST CARD

### 1 YEAR LIMITS

Hewlett-Packard Model 3468A/B  
Digital Multimeter

Test Performed By \_\_\_\_\_  
Date \_\_\_\_\_

Serial Number \_\_\_\_\_

Reference Temperature \_\_\_\_\_

#### AC Current Test

Step#	Input to 3468A/B	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET				—	—
2	Open	ACI Function				—	—
3	.03A, 5KHz	.3A Range	.030463A	_____	.029537A	—	—
4	0.1A, 5KHz	.3A Range	.101163A	_____	.098837A	—	—
5	1A, 5KHz	3A Range	1.01863A	_____	0.98137A	—	—

## OHMS PERFORMANCE TEST CARD

### 24 HOUR LIMITS

Hewlett-Packard Model 3468A/B  
Digital Multimeter

Test Performed By \_\_\_\_\_  
Date \_\_\_\_\_

Serial Number \_\_\_\_\_

Reference Temperature \_\_\_\_\_

#### Ohms Test

Step#	Input to 3468A/B	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET				—	—
2	Short	300 Range	000.004	_____	-000.004	—	—
3	Short	3K Range	0.00002K	_____	-0.00002K	—	—
4	Short	30K Range	00.0002K	_____	-00.0002K	—	—
5	Short	300K Range	000.002K	_____	-000.002K	—	—
6	Short	3M Range	0.00002M	_____	-0.00002M	—	—
7	Short	30M Range	00.0002M	_____	-00.0002M	—	—
8	300 ohm	300 Range	300.012	_____	299.988	—	—
(8)	100 ohm		100.004	_____	099.996	—	—
9	3K ohm	3K Range	3.00014K	_____	2.99986K	—	—
(9)	1K ohm		1.00006K	_____	0.99994K	—	—
10	30K ohm	30K Range	30.0014K	_____	29.9986K	—	—
(10)	10K ohm		10.0006K	_____	09.9994K	—	—
11	300K ohm	300K Range	300.014K	_____	299.986K	—	—
(11)	100K ohm		100.006K	_____	099.994K	—	—
12	3M ohm	3M Range	3.00017M	_____	2.99983M	—	—
(12)	1M ohm		1.00007M	_____	0.99993M	—	—
13	30M ohm	30M Range	30.0110M	_____	29.9890M	—	—
(13)	10M ohm		10.0038M	_____	09.9962M	—	—

# OHMS PERFORMANCE TEST CARD

Hewlett-Packard Model 3468A/B  
Digital Multimeter

## 90 DAY LIMITS

Test Performed By \_\_\_\_\_  
Date \_\_\_\_\_

Serial Number \_\_\_\_\_

Reference Temperature \_\_\_\_\_

### Ohms Test

Step#	Input to 3468A/B	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET				—	—
2	Short	300 Range	000.004	—	—000.004	—	—
3	Short	3K Range	0.00002K	—	—0.00002K	—	—
4	Short	30K Range	00.0002K	—	—00.0002K	—	—
5	Short	300K Range	000.002K	—	—000.002K	—	—
6	Short	3M Range	0.00002M	—	—0.00002M	—	—
7	Short	30M Range	00.0002M	—	—00.0002M	—	—
8	300 ohm	300 Range	300.041	—	299.959	—	—
(8)	100 ohm		100.017	—	099.983	—	—
9	3K ohm	3K Range	3.00035K	—	2.99965K	—	—
(9)	1K ohm		1.00013K	—	0.99987K	—	—
10	30K ohm	30K Range	30.0035K	—	29.9965K	—	—
(10)	10K ohm		10.0013K	—	09.9987K	—	—
11	300K ohm	300K Range	300.035K	—	299.965K	—	—
(11)	100K ohm		100.013K	—	099.987K	—	—
12	3M ohm	3M Range	3.00035M	—	2.99965M	—	—
(12)	1M ohm		1.00013M	—	0.99987M	—	—
13	30M ohm	30M Range	30.0200M	—	29.9800M	—	—
(13)	10M ohm		10.0068M	—	09.9932M	—	—



# OHMS PERFORMANCE TEST CARD

## 1 YEAR LIMITS

Hewlett-Packard Model 3468A/B  
Digital Multimeter

Test Performed By \_\_\_\_\_  
Date \_\_\_\_\_

Serial Number \_\_\_\_\_

Reference Temperature \_\_\_\_\_

### Ohms Test

Step#	Input to 3468A/B	Set-Up and Configuration	High Limit	Reading	Low Limit	Test Pass	Test Fail
1	Open	Press TEST/RESET					
2	Short	300 Range	000.005	_____	- 000.005	_____	_____
3	Short	3K Range	0.00002K	_____	- 0.00002K	_____	_____
4	Short	30K Range	00.0002K	_____	- 00.0002K	_____	_____
5	Short	300K Range	000.002K	_____	- 000.002K	_____	_____
6	Short	3M Range	0.00002M	_____	- 0.00002M	_____	_____
7	Short	30M Range	00.0002M	_____	- 00.0002M	_____	_____
8	300 ohm	300 Range	300.056	_____	299.944	_____	_____
(8)	100 ohm		100.022	_____	099.978	_____	_____
9	3K ohm	3K Range	3.00050K	_____	2.99950K	_____	_____
(9)	1K ohm		1.00018K	_____	0.99982K	_____	_____
10	30K ohm	30K Range	30.0050K	_____	29.9950K	_____	_____
(10)	10K ohm		10.0018K	_____	09.9982K	_____	_____
11	300K ohm	300K Range	300.050K	_____	299.950K	_____	_____
(11)	100K ohm		100.018K	_____	099.982K	_____	_____
12	3M ohm	3M Range	3.00050M	_____	2.99950M	_____	_____
(12)	1M ohm		1.00018M	_____	0.99982M	_____	_____
13	30M ohm	30M Range	30.0236M	_____	29.9764M	_____	_____
(13)	10M ohm		10.0080M	_____	09.9920M	_____	_____

# SECTION V

## REPLACEABLE PARTS

### 5-1. INTRODUCTION

5-2. This section has information for ordering replacement parts. Table 5-3 lists the parts in alphameric order of their reference designators and indicates the description, -hp- Part Number of each part, together with any applicable notes, and provides the following:

- Total quantity used in the instrument (QTY column). The total quantity of a part is given the first time the part number appears.
- Description of the part. (See abbreviations listed in Table 5-1.)
- Typical manufacturer of the part is a five-digit code. (See Table 5-2 for list of manufacturers.)
- Manufacturers part number.

5-3. Miscellaneous and Chassis Parts are listed at the end of Table 5-3. A disassembly procedure of the instrument is also included with the Miscellaneous and Chassis Parts listing.

### 5-4. ORDERING INFORMATION

5-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Office. (Office Loca-

tions are listed at the back of this manual.) Identify parts by their Hewlett-Packard Part Numbers. Include instrument model and serial number.

### 5-6. NON-LISTED PARTS

5-7. To obtain a part that is not listed, include:

- Instrument Model Number
- Instrument Serial Number
- Description of the part
- Function and location of the part

### 5-8. PARTS CHANGES

5-9. Components which have been changed are so marked by one of three symbols; i.e.,  $\Delta$ ,  $\Delta$  with a letter subscript, e.g.,  $\Delta_a$ , or  $\Delta$  with a number subscript, e.g.,  $\Delta_{10}$ . A  $\Delta$  with no subscript indicates the component listed is the preferred replacement for an earlier component. A  $\Delta$  with a letter subscript indicates a change which is explained in a note at the bottom of the page. A  $\Delta$  with a number subscript indicates the related change is discussed in backdating (Section VI). The number of the subscript indicates the number of the change in backdating which should be referred to.

### 5-10. PROPRIETY PARTS

Table 5-1. Standard Abbreviations

ABBREVIATIONS			
Ag .....	silver	Hz .....	hertz (cycle(s) per second)
Al .....	aluminum	ID .....	inside diameter
A .....	ampere(s)	imp .....	impregnated
Au .....	gold	incd .....	incandescent
C .....	capacitor	ins .....	insulation(ed)
cer .....	ceramic	k $\Omega$ .....	kilohm(s) = $10^3$ ohms
coef .....	coefficient	kHz .....	kilohertz = $10^3$ hertz
com .....	common	L .....	inductor
comp .....	composition	lin. ....	linear taper
conn .....	connection	log .....	logarithmic taper
dep .....	deposited	mA .....	milliampere(s) = $10^{-3}$ amperes
DPDT .....	double-pole double-throw	MHZ .....	megahertz = $10^6$ hertz
DPST .....	double-pole single-throw	M $\Omega$ .....	megohm(s) = $10^6$ ohms
elect .....	electrolytic	met film .....	metal film
encap .....	encapsulated	mfr .....	manufacturer
F .....	farad(s)	ms .....	millisecond
FET .....	field effect transistor	mtg .....	mounting
fxd .....	fixed	mV .....	millivolt(s) = $10^{-3}$ volts
GaAs .....	gallium arsenide	$\mu$ F .....	microfarad(s)
GHz .....	gigahertz = $10^9$ hertz	$\mu$ S .....	microsecond(s)
gd .....	guarded	$\mu$ V .....	microvolt(s) = $10^{-6}$ volts
Ge .....	germanium	my .....	Mylar $\text{\textcircled{C}}$
gnd .....	ground(ed)	nA .....	nanoampere(s) = $10^{-9}$ amperes
H .....	henry(ies)	NC .....	normally closed
Hg .....	mercury	Ne .....	neon
		NO .....	normally open
DESIGNATORS			
A .....	assembly	FL .....	filter
B .....	motor	HR .....	heater
BT .....	battery	IC .....	integrated circuit
C .....	capacitor	J .....	jack
CR .....	diode or thyristor	K .....	relay
DL .....	delay line	L .....	inductor
DS .....	lamp	M .....	meter
E .....	misc electronic part	MP .....	mechanical part
F .....	fuse	P .....	plug
NPO .....	negative positive zero (zero temperature coefficient)	Q .....	transistor
ns .....	nanosecond(s) = $10^{-9}$ seconds	QCR .....	transistor-diode
nsr .....	not separately replaceable	Rip .....	resistor(pack)
$\Omega$ .....	ohm(s)	RT .....	thermistor
obd .....	order by description	S .....	switch
OD .....	outside diameter	T .....	transformer
p .....	peak	TB .....	terminal board
pA .....	picoampere(s)	TC .....	thermocouple
pc .....	printed circuit	TP .....	test point
pF .....	picofarad(s) $10^{-12}$ farads		
piv .....	peak inverse voltage		
p/o .....	part of		
pos .....	position(s)		
poly .....	polystyrene		
pot .....	potentiometer		
p-p .....	peak-to-peak		
ppm .....	parts per million		
prec .....	precision (temperature coefficient, long term stability and/or tolerance)		
R .....	resistor		
Rh .....	rhodium		
rms .....	root-mean-square		
rot .....	rotary		
Se .....	selenium		
sect .....	section(s)		
Si .....	silicon		
sl .....	slide		
SPDT .....	single-pole double-throw		
SPST .....	single-pole single-throw		
Ta .....	tantalum		
TC .....	temperature coefficient		
TiO <sub>2</sub> .....	titanium dioxide		
tog .....	toggle		
tol .....	tolerance		
trim .....	trimmer		
TSTR .....	transistor		
V .....	volt(s)		
vacw .....	alternating current working voltage		
var .....	variable		
vdew .....	direct current working voltage		
W .....	watt(s)		
w/ .....	with		
wiv .....	working inverse voltage		
w/o .....	without		
ww .....	wirewound		
* .....	optimum value selected at factory.		
* .....	average value shown (part may be omitted)		
* .....	no standard type number assigned selected or special type		
	$\text{\textcircled{C}}$ Dupont de Nemours		
TS .....	terminal strip		
U .....	microcircuit		
V .....	vacuum tube, neon bulb, photocell, etc.		
W .....	cable		
X .....	socket		
XDS .....	lampholder		
XF .....	fusiholder		
Y .....	crystal		
Z .....	network		



Table 5-2. Code List of Manufacturers

Mfr Code	Manufacturer's Name	Address	Zip Code
00779	AMP INC	HARRISBURG PA	17111
01121	ALLEN-BRADLEY CO INC	EL PASO TX	79935
01295	TEXAS INSTRUMENTS INC	DALLAS TX	75265
01961	PULSE ENGINEERING INC	SAN DIEGO CA	92111
03890	MARKEL CORP	NORRISTOWN PA	19404
04222	AVX CORP	GREAT NECK NY	11021
04713	MOTOROLA INC	ROSELLE IL	60195
06665	PRECISION MONOLITHICS INC	SANTA CLARA CA	95054
11236	CTS CORP	ELKHART IN	46514
11502	IRC INC	BOONE NC	28607
13103	THERMALLOY INC	DALLAS TX	75234
16428	COOPER INDUSTRIES INC	HOUSTON TX	77210
17856	SILICONIX INC	SANTA CLARA CA	95054
19701	MEPCO/CENTRALAB INC	WEST PALM BEACH FL	33407
24355	ANALOG DEVICES INC	NORWOOD MA	02062
25403	NV PHILIPS ELCOMA	EINDHOVEN NETHERLANDS	02876
27014	NATIONAL SEMICONDUCTOR CORP	SANTA CLARA CA	95052
27264	MOLEX INC	LISLE IL	60532
28480	HEWLETT-PACKARD CO CORPORATE HEADQUARTERS	PALO ALTO CA	94304
30043	SOLID STATE DEVICES INC	LA MIRADA CA	90638
34333	SILICON GENERAL INC	SAN JOSE CA	95134
52763	STETTNER & CO	LAUF GERMANY	D-856
56289	SPRAGUE ELECTRIC CO	LEXINGTON MA	02173
71707	COTO CORP	PROVIDENCE RI	02907
72799	GENERAL ELECTRIC CO	FAIRFIELD CT	06430
75263	KEYSTONE CARBON CO INC	ST MARY PA	15857
78189	ILLINOIS TOOL WORKS INC SHAKEPROOF	ELGIN IL	60126
81073	GRAYHILL INC	LA GRANGE IL	60525
81654	MONITOR PRODUCTS CO INC	OCEANSIDE CA	92054
82389	SWITCHCRAFT INC	CHICAGO IL	60630
84411	AMERICAN SHIZUKI CORP	CANOGA PARK CA	91304
91418	RADIO MATERIALS CO	CHICAGO IL	60646
91637	DALE ELECTRONICS INC	COLUMBUS NE	68601
99800	AMER PRCN IND INC DELEVAN DIV	AURORA NY	14052

5-11. Items marked with a dagger (†) in the reference designator column are available only for repair and service of Hewlett-Packard Instruments.

#### 5-12. 3468A/B DISASSEMBLY

5-13. The following paragraphs have the complete disassembly procedures for the 3468A/B. The procedures also includes the disassembly of the Battery Circuitry (Option 001).



*To prevent leakage paths on the main printed circuit board, hold and/or handle the board by the power transformer only.*



*After reassembling the 3468A/B, make sure the cable between the battery circuitry and main printed circuit board is in the correct position, or the battery can be discharged and the power fuse may open.*

#### 5-14. 3468A Disassembly

5-15. The following is the disassembly procedure for the 3468A. For the 3468B disassembly procedure, go to paragraph 5-16.

a. Make sure the 3468A is turned off and ac power is disconnected from the instrument.

b. Place the instrument into the inverted position. Refer to Figure 5-2 and locate screws MP3. Loosen all four screws, but do not attempt to remove them from the bottom assembly (MP6). The screws are held in the assembly by "O" rings.

c. Turn the 3468A rightside up facing you. Lift the 3468A's top assembly (MP7) up about an inch or so, away from the bottom assembly. Then place the top assembly next to the bottom assembly, as shown in Figure 5-3.

d. If the battery option is installed, disconnect battery cable (W901) from the A1 assembly (see Figures 5-3 and 5-4). If the battery and/or the battery charger circuitry board is to be removed, do the following:

1. Refer to Figure 5-8. Disconnect the wires from the battery and then loosen and remove screws MP18.
2. The battery circuitry board can now be removed. Once the board is removed, remove the battery cover (MP20) and then the battery.
3. The battery and battery circuitry board is now removed from the top assembly.

d. Remove handle MP5 from the bottom assembly.

e. If the display (MP16) is to remain in the 3468A, continue with step f. If the display is to be removed, do the following:

1. Refer to Figure 5-7. Unplug cable W501 from the display assembly.
2. Loosen and remove screws MP15 from the front panel assembly (MP2).
3. Remove the display assembly.

f. Refer to Figure 5-4. Loosen and remove screw MP9 from the inner shield (MP10). Then remove the inner shield.

g. Refer to Figure 5-5. Loosen and remove screws MP11 from the A1 assembly (main printed circuit board).

h. Remove the A1 assembly by lifting it up and out of the 3468A's bottom assembly (MP6). Set the bottom assembly aside.

i. Refer to Figure 5-7. Unplug cable W501 from the display assembly (MP16). Then unplug the wires from the front panel terminals.

j. Refer to Figure 5-7. Loosen and remove screws MP17 from the A1 assembly. Remove the front panel assembly from the A1 assembly. The instrument is now disassembled.

### 5-16. 3468B Disassembly

5-17. The following is the disassembly procedure for the 3468B. For the 3468A disassembly procedure, go to paragraph 5-14.

a. Make sure the 3468B is turned off and ac power is disconnected from the instrument.

b. Place the instrument into the inverted position. Refer to Figure 5-10 and locate the two rear feet (MP8) and then remove the feet. To remove a foot, lift up the

tab on the foot and then push the foot toward the front of the instrument. Then lift the foot away from the instrument.

c. Refer to Figure 5-10 and locate screws MP3. Loosen all four screws, but do not attempt to remove them from the bottom assembly (MP7). The screws are held in the assembly by "O" rings.

d. Turn the 3468B rightside up facing you. Lift the 3468B's top assembly (MP7) up about an inch or so, away from the bottom assembly. Then place the top assembly next to the bottom assembly, as shown in Figure 5-11.

e. If the battery option is installed, disconnect battery cable (W901) from the A1 assembly (see Figure 5-11 and 5-12). If the battery and/or the battery charger circuitry board is to be removed, do the following:

1. Refer to Figure 5-16. Disconnect the wires from the battery and then loosen and remove screws MP22.
2. The battery circuitry board can now be removed. Once the board is removed, remove the battery cover (MP23) and then the battery.
3. The battery and battery circuitry board is now removed from the top assembly.

f. If the display (MP19) is to remain in the 3468B, continue with step g. If the display is to be removed, do the following:

1. Refer to Figure 5-15. Unplug cable W501 from the display assembly.
2. Loosen and remove screws MP18 from the front panel assembly (MP2).
3. Remove the display assembly.

g. Refer to Figure 5-12. Loosen and remove screw MP11 from the inner shield (MP12). Then remove the inner shield.

h. Refer to Figure 5-13. Loosen and remove screws MP13 from the A1 assembly (main printed circuit board).

i. Remove the A1 assembly by lifting it up and out of the 3468B's bottom assembly (MP7). Set the bottom assembly aside.

j. Refer to Figure 5-15. Unplug cable W501 from the display assembly (MP19). Then unplug the wires from the front panel terminals.

k. Refer to Figure 5-15. Loosen and remove screws MP20 from the A1 assembly. Remove the front panel assembly from the A1 assembly. The instrument is now disassembled.



Table 5-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1	03468-66510	1	1	MOTHER BOARD	28480	03468-66510
BT551	1420-0278	7	1	BATTERY 2.9V .72A-HR LI/S-DIOX W-FLEX	28480	1420-0278
C101-C103	0160-6839	5	3	CAPACITOR-FXD 470PF +-2% 630VDC POLYP	28480	0160-6839
C104 <sup>2</sup>	0150-0012	3	1	CAPACITOR-FXD .01UF +-20% 1KVDC CER	91418	B-HD/.01/+ OR -20%
C109	0160-4571	8	11	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	SA105E104ZAA
C201	0160-4800	6	2	CAPACITOR-FXD 120PF +-5% 100VDC CER	04222	SA106A121JAA
C202-C203	0160-4832	4	4	CAPACITOR-FXD .01UF +-10% 100VDC CER	04222	SA201C103KAA
C204	0160-6396	9	1	CAPACITOR-FXD 470PF +-10% 200VDC CER	04222	MA206C471KAA
C205	0160-6386	7	1	CAPACITOR-FXD 24PF +-1PF 630VDC POLYP	28480	0160-6386
C301	0160-5386	5	1	CAPACITOR-FXD .15UF +-10% 630VDC	19701	701B1LH154PK631SX
C302	0160-5384	3	1	CAPACITOR-FXD 2.7PF +- .1PF 400VDC CER	52763	PDAL-3 2.7PF+-0.1P
C304	0180-0228	6	2	CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
C305	0160-4803	9	1	CAPACITOR-FXD 68PF +-5% 100VDC CER 0+-30	04222	SA101A680JAA
C306	0180-0228	6		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
C307	0160-5385	4	1	CAPACITOR-FXD 1.8UF +-10% 100VDC	19701	701A1LH185PK101SX
C308	0180-2205	3	1	CAPACITOR-FXD .33UF+-10% 35VDC TA	56289	150D334X9035A2
C309	0180-0373	2	1	CAPACITOR-FXD .68UF+-10% 35VDC TA	56289	150D684X9035A2
C310	0180-0291	3	3	CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
C311-C312	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	SA105E104ZAA
C313	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
C401-C402	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	SA105E104ZAA
C404-C405	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	SA105E104ZAA
C410	0160-5392	3	1	CAPACITOR-FXD 1500PF +-10% 400VDC POLYP	84411	HEW-602
C411	0160-4814	2	1	CAPACITOR-FXD 150PF +-5% 100VDC CER	04222	SA101A151JAA
C412	0160-4830	2	2	CAPACITOR-FXD 2200PF +-10% 100VDC CER	04222	SA101C222KAA
C430	0160-4823	3	1	CAPACITOR-FXD 820PF +-5% 100VDC CER	04222	SA101A821JAA
C431	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	04222	SA201C103KAA
C501	0160-3335	0	1	CAPACITOR-FXD 470PF +-10% 100VDC CER	04222	SA101C471KAA
C503	0160-4532	1	1	CAPACITOR-FXD 1000PF +-20% 50VDC CER	04222	SA105C102MAA
C504	0160-4800	6		CAPACITOR-FXD 120PF +-5% 100VDC CER	04222	SA106A121JAA
C505-C506	0160-4807	3	2	CAPACITOR-FXD 33PF +-5% 100VDC CER 0+-30	04222	SA102A330JAA
C507	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	SA105E104ZAA
C508 <sup>1</sup>	0160-4810	8	1	CAPACITOR-FXD 330PF +-5% 100VDC CER	04222	SA101A331JAA
C509 <sup>1</sup>	0160-4810	8	1	CAPACITOR-FXD 330PF +-5% 100VDC CER	04222	SA101A331JAA
C519	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	SA105E104ZAA
C550	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	SA105E104ZAA
C551	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
C552	0160-4830	2		CAPACITOR-FXD 2200PF +-10% 100VDC CER	04222	SA101C222KAA
C702-C703	0180-3871	1	4	CAPACITOR-FXD 330UF+-20% 50VDC AL	56289	513D337M050DG3C
C705-C706	0180-0117	2	2	CAPACITOR-FXD 2.7UF+-10% 35VDC TA	56289	150D275X9035B2

1 These components apply only to the 03468-66501 Mother Board which was used in 3468As with serial numbers of 2137A03600 and below.

2 For instrument serial numbers of 2137A11665 and above (IIP 3468A) or 2231A02326 and above (IIP 3468B): RV101 is used in place of C104. For instrument serial numbers below 2137A11665 (HP 3468A) or below 2231A02326 (IIP 3468B): C104 is used in place of RV101 and HP part number 1970-0090 (630V) is used for E101.



Table 5-3. Replaceable Parts (A1 Cont.)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
C707	0160-4571	8		CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	SA105E104ZAA
C731	0180-3876	6	1	CAPACITOR-FXD 1000UF+-20% 25VDC AL	28480	0180-3876
C740-C741	0180-3871	1	1	CAPACITOR-FXD 330UF+-20% 50VDC AL	56289	513D337M050DG3C
C742	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	04222	SA201C103KAA
CR201	1901-0849	8	1	DIODE-PWR RECT 1N4007 1KV 1A DO-41	30043	1N4007
CR202	1902-0184	6	1	DIODE-ZNR 16.2V 5% DO-35 PD=.4W	28480	1902-0184
CR401	1826-0918	2	1	IC V RGLTR-FXD-POS 6.6/7.25V TO-92 PKG	27014	LM329BZ
CR501	1901-0040	1	1	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
CR520	1910-0016	0	1	DIODE-GE 60V 60MA 1US DO-7	28480	1910-0016
CR521	1902-1430	7	1	DIODE-ZNR 6.2V 10% DO-35 PD=.4W	04713	.4M6.2ZZ10
CR550-CR551	1901-0050	3	3	DIODE-SWITCHING 80V 200MA 2NS DO-35	25403	BAV10 SELECTED
CR552 <sup>1</sup>	1902-0970	8	1	DIODE-ZNR 33V 5% DO-35 PD=.4W TC=+.097%	28480	1902-0970
CR553 <sup>1</sup>	1902-0970	8	1	DIODE-ZNR 33V 5% DO-35 PD=.4W TC=+.097%	28480	1902-0970
CR554 <sup>1</sup>	1901-0050	3	1	DIODE-SWITCHING 80V 200MA 2NS DO-35	25403	BAV10 SELECTED
CR555 <sup>1</sup>	1901-0050	3	1	DIODE-SWITCHING 80V 200MA 2NS DO-35	25403	BAV10 SELECTED
CR556	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	25403	BAV10 SELECTED
CR701-CR707	1901-0743	1	9	DIODE-PWR RECT 1N4004 400V 1A DO-41	28480	1901-0743
CR711	1902-0632	9	2	DIODE-ZNR 1N5354B 17V 5% PD=5W TC=+75%	04713	1N5354B
CR712	1902-0936	6	1	DIODE-ZNR 6V PD=5W IR=300UA	28480	1902-0936
CR713	1902-0632	9		DIODE-ZNR 1N5354B 17V 5% PD=5W TC=+75%	04713	1N5354B
CR749-CR750	1902-0654	5	2	DIODE-ZNR 33V 5% PD=1W IR=5UA	28480	1902-0654
CR751-CR752	1901-0743	1		DIODE-PWR RECT 1N4004 400V 1A DO-41	28480	1901-0743
E101 <sup>2</sup>	1970-0100	9	1	TUBE-ELECTRON SURGE V PTCTR	28480	1970-0100
F730	2110-0234	9	1	FUSE .1A 250V TD FE UL	16428	MDL 1/10,
HSK701	1205-0309	9	1	HEAT SINK SGL TO-220-CS	13103	6038D
JM303	7175-0057	5	2	RESISTOR-ZERO OHMS SOLID TINNED COPPER	28480	7175-0057
JM510	7175-0057	5		RESISTOR-ZERO OHMS SOLID TINNED COPPER	28480	7175-0057
K101	0490-1556	2	1	RELAY-REED 2A 250MA 400VDC 5VDC-COIL	71707	3500-0050
K102-K104	0490-1555	1	3	RELAY-REED 2A 250MA 400VDC 5VDC-COIL	71707	3500-0051
L201 <sup>4</sup>	9100-1666	9	1	INDUCTOR RF-CH-MLD 3.6MH +-5%	99800	2500-54
L501	9100-1631	8	1	INDUCTOR RF-CH-MLD 56UH +-5%	99800	1537-64
LBL002	7120-3530	0	1	LABEL, VOLTAGE WARNING	28480	7120-3530
LBL003	7120-6830	9	1	LABEL-INFORMATION .25-IN-WD .625-IN-LG	28480	7120-6830
MP014	1600-1184	8	2	STAMPING-BE-CU CONNECTOR STRIP-21 PIN	28480	1600-1184
MP100	1460-1485	4	1	FUSE SPRING (INSIDE FUSE HOLDER)	28480	1460-1485
MP101	5040-8068	7	1	FUSE HOLDER (ON PC BOARD)	28480	5040-8068
P702	1251-4743	0	1	CONNECTOR-AC PWR HP-9 MALE REC-FLG THRMP	82389	EAC303
Q201-Q204	1853-0510	7	4	TRANSISTOR PNP TO-92 PD=625MW	28480	1853-0510
Q205	1855-0298	2	1	TRANSISTOR J-FET N-CHAN D-MODE TO-92	17856	J2472

1 These components apply only to the 03468-66501 Mother Board which was used in 3468As with serial numbers of 2137A03600 and below.

2 For serial numbers of 2137A11665 and above (IIP 3468A) or 2231A02326 and above (IIP 3468B): RV101 is used in place of C104. For serial numbers below 2137A11665 (IIP 3468A) or below 2231A02326 (IIP 3468B): C104 is used in place of RV101 and IIP part number 1970-0090 (630V) is used for E101.

4 For the 03468-66510 Mother Board with an ERC below 2623, substitute the following IIP part numbers: 0686-5135 (51kΩ) for R109; 0683-4715 (470kΩ) for R204; 9100-1651 (750μH) for L201; and 0683-2445 (240kΩ) for R202 & R203.

Table 5-3. Replaceable Parts (A1 Cont.)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
Q510-Q511	1853-0066	8	2	TRANSISTOR PNP SI TO-92 PD=625MW	28480	1853-0066
R101-R106	0686-5135	6	6	RESISTOR 51K 5% .5W CC TC=0+765	01121	EB5135
R107	0811-3435	2	1	RESISTOR .1 .1% 3W PW TC=0+90	91637	RS2B-227
R108 <sup>3</sup>	0686-5135	6	1	RESISTOR 51K 5% .5W CC TC=0+765	01121	EB5135
R109 <sup>4</sup>	0683-1655	1	2	RESISTOR 1.6M 5% .25W CF TC=0-900	28480	0683-1655
R110	0698-8777	3	5	RESISTOR 1K 5% .25W CC TC=-400/+900	01121	CB1025
R201	5180-0221	4	1	R-F 40K .1% AGED	28480	5180-0221
R202 <sup>4</sup>	0698-3149	3	2	RESISTOR 255K 1% .125W TF TC=0+-100	19701	SFR25H
R203 <sup>4</sup>	0698-3149	3	2	RESISTOR 255K 1% .125W TF TC=0+-100	19701	SFR25H
R204 <sup>4</sup>	0683-3925	2	1	RESISTOR 3.9K 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-3K9
R205	0683-4325	8	1	RESISTOR 4.3K 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-4K3
R206	0683-1535	6	4	RESISTOR 15K 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-15K
R302	0698-6670	1	1	RESISTOR 1K .5% .125W TF TC=0+-25	19701	5033R
R303	0698-6520	0	1	RESISTOR 24K .25% .125W TF TC=0+-25	91637	CMF-55-1
R304	0683-2435	7	1	RESISTOR 24K 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-24K
R305	0757-0457	6	1	RESISTOR 47.5K 1% .125W TF TC=0+-100	19701	SFR25H
R306-R307	0683-1005	5	3	RESISTOR 10 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-10E
R401	0683-1655	1		RESISTOR 1.6M 5% .25W CF TC=0-900	28480	0683-1655
R402	0698-8353	1	1	RESISTOR 806K 1% .125W TF TC=0+-100	19701	5033R
R403	0698-4539	7	1	RESISTOR 402K 1% .125W TF TC=0+-100	19701	SFR25H
R404	0757-0472	5	2	RESISTOR 200K 1% .125W TF TC=0+-100	19701	SFR25H
R405	0757-0465	6	1	RESISTOR 100K 1% .125W TF TC=0+-100	19701	SFR25H
R406	0698-3228	9	1	RESISTOR 49.9K 1% .125W TF TC=0+-100	19701	SFR25H
R407	0683-8255	1	1	RESISTOR 8.2M 5% .25W CC TC=-900/+1100	01121	CB8255
R408	0683-1005	5		RESISTOR 10 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-10E
R409	0757-0415	6	1	RESISTOR 475 1% .125W TF TC=0+-100	19701	SFR25H
R438	0757-0273	4	1	RESISTOR 3.01K 1% .125W TF TC=0+-100	19701	SFR25H
R439	0757-0472	5		RESISTOR 200K 1% .125W TF TC=0+-100	19701	SFR25H
R502	0698-8827	4	2	RESISTOR 1M 1% .125W TF TC=0+-100	19701	SFR25H
R503 <sup>1</sup>	0683-1535	6	1	RESISTOR 15K 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-15K
R504 <sup>1</sup>	0683-1535	6	1	RESISTOR 15K 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-15K
R505 <sup>1</sup>	0698-3446	3	1	RESISTOR 383 1% .125W TF TC=0+-100	19701	SFR25H
R506 <sup>1</sup>	0698-3446	3	1	RESISTOR 383 1% .125W TF TC=0+-100	19701	SFR25H
R507	0683-1535	6		RESISTOR 15K 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-15K
R551	0698-4482	9	1	RESISTOR 17.4K 1% .125W TF TC=0+-100	91637	CMF-55-1, T-1
R552	0698-3359	7	2	RESISTOR 12.7K 1% .125W TF TC=0+-100	19701	SFR25H
R553	0698-8827	4		RESISTOR 1M 1% .125W TF TC=0+-100	19701	SFR25H
R554	0683-1535	6		RESISTOR 15K 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-15K
R562	0698-3359	7		RESISTOR 12.7K 1% .125W TF TC=0+-100	19701	SFR25H
R564-R565	0698-8777	3		RESISTOR 1K 5% .25W CC TC=-400/+900	01121	CB1025
R567	0698-8777	3		RESISTOR 1K 5% .25W CC TC=-400/+900	01121	CB1025

1 These components apply only to the 03468-66501 Mother Board which was used in 3468As with serial numbers of 2137A03600 and below.

3 R108 is not used in instruments with serial numbers of 2137A13090 and above (IIP 3468A) or 2231A02931 and above (HP 3468B).

4 For the 03468-66510 Mother Board with an ERC below 2623, substitute the following IIP part numbers: 0686-5135 (51kΩ) for R109; 0683-4715 (470kΩ) for R204; 9100-1651 (750μH) for L201; and 0683-2445 (240kΩ) for R202 & R203.



Table 5-3. Replaceable Parts (A1 Cont.)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
R570-R571	0683-2425	5	2	RESISTOR 2.4K 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-2K4
R708	0698-8777	3		RESISTOR 1K 5% .25W CC TC=-400/+900	01121	CB1025
R740	0812-0040	1	1	RESISTOR .27 5% .5W PW TC=0+-300	11502	SP-20
R741	0683-1535	6		RESISTOR 15K 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-15K
RP501	1810-0162	5	1	NETWORK-RES 14-DIP 4.7K OHM X 13	11236	760-1-R4.7K
RP561	1810-0560	7	1	NETWORK-RES 16-DIP 5.6K OHM X 8	11236	761-3-R5.6K+-1%
RP568	1810-0269	3	1	NETWORK-RES 9-SIP 10.0K OHM X 8	56289	216CJ104
RT563	0837-0220	1	1	THERMISTOR ROD 10K-OHM TC=-3.83%/C-DEG	75263	AL1545-6240-73-S6
RT706-RT707	0837-0223	4	2	THERMISTOR DISC 10-OHM	75263	RL4008-10-110-40-P
RV101 <sup>2</sup>	0837-0318	8	1	VOLTAGE SUPPRESSOR VMAC=230V, VMDC=300V	28480	0837-0318
S730	3101-1723	5	1	SWITCH-PB 4PDT ALTNG .45A 115 VAC	19701	2KAB001000520
SP501	3101-2243	6	1	SWITCH-DIP RKR 8-1A 0.05A 30VDC	81073	76YY22318S
T501 <sup>1</sup>	9100-4197	7	1	TRANSFORMER SWITCHING POWER SUPPLY	28480	9100-4197
T502 <sup>1</sup>	9140-0600	3	1	TRANSFORMER-PULSE TURNS RATIO 3:1 +-1%	28480	9140-0600
T503	9100-4275	2	1	TRANSFORMER-ISOLATION HP-IL TURNS RATIO	01961	PE63577
T730	9100-4202	5	1	TRANSFORMER-POWER 100/120/220/240V	28480	9100-4202
TP001	1251-0600	0	8	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	27264	16-06-0034
U101	1826-1056	1	1	IC OP AMP PRCN 8-TO-99 PKG	24355	AD542KH
U102	1QF7-0067	6	1	KEY INPUT HYBRID	28480	1QF7-0067
U201-U202	1826-0493	8	2	IC OP AMP LOW-BIAS-H-IMPD 8-DIP-P PKG	27014	LM308AN
U203	1826-0072	9	1	IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	27014	LM208H
U301	1826-0887	4	1	IC OP AMP LOW-BIAS-H-IMPD DUAL 8-DIP-P	27014	LF412CN (SELECTED)
U302	1826-1010	7	1	IC OP AMP WB 8-TO-99 PKG	27014	LF357H SELECTED
U303	1826-0893	2	1	RMS/DC 10-METAL BPLR	24355	AD536AJH (BURNED-I
U401	1826-0311	9	1	IC OP AMP GP 8-DIP-P PKG	04713	LM201AN
U402	1826-0635	0	2	IC OP AMP LOW-OFS 8-DIP-P PKG	06665	OP-07CP
U403	1QF6-0066	3	1	KEY A/D HYBRID	28480	1QF6-0066
U404	1826-0271	0	1	IC OP AMP GP 8-DIP-P PKG	27014	LM741CN
U405	1826-0635	0		IC OP AMP LOW-OFS 8-DIP-P PKG	06665	OP-07CP
U501	1820-2718	2	1	IC-8-BIT MICROPROCESSOR WITH RAM (128X8)	27014	INS8039LN-11
U502 <sup>5</sup>	03468-65501	8	1	EPROM	28480	03468-65501
U503	1LR4-0002	2	1	IC-HPIL 28 PIN	28480	1LR4-0002
U504	1820-2702	4	1	IC DIVR CMOS DIVIDE-BY-24	04713	MC14521BCP
U505	1820-1578	0	2	IC SHF-RGTR CMOS D-TYPE PRL-IN PRL-OUT 4	72799	CD4076BE
U507	1820-1578	0		IC SHF-RGTR CMOS D-TYPE PRL-IN PRL-OUT 4	72799	CD4076BE
U508	1820-2102	8	1	IC LCH TTL LS D-TYPE OCTL	01295	SN74LS373N
U509	1818-1754	9	1	IC CMOS 1024 (1K) STAT RAM 650-NS 3-S	28480	1818-1754
U550	1826-0412	1	1	IC COMPARATOR PRCN DUAL 8-DIP-P PKG	27014	LM393N
U701	1826-0551	9	1	IC V RGLTR-FXD-POS 4.9/5.1V TO-220 PKG	27014	LM340AT-5
U702	1826-0214	1	1	IC V RGLTR-FXD-NEG 14.4/15.6V TO-220 PKG	04713	MC7915CT

1 These components apply only to the 03468-66501 Mother Board which was used in 3468As with serial numbers of 2137A03600 and below.

2 For serial numbers of 2137A11665 and above (IIP 3468A) or 2231A02326 and above (IIP 3468B): RV101 is used in place of C104. For serial numbers below 2137A11665 (IIP 3468A) or below 2231A02326 (IIP 3468B): C104 is used in place of RV101 and IIP part number 1970-0090 (630V) is used for E101.

5 For 03468-66510 Mother Boards with an ERC below 2723; substitute IIP part number 1818-3123 for U502.



Table 5-3. Replaceable Parts (A1 Cont.)

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
U703	1826-0607	6	1	IC V RGLTR-FXD-POS 14.7/15.3V TO-220 PKG	27014	LM340AT-15
W101	5061-1181	5	1	CBL BK 100MM FEP	28480	5061-1181
W102	5061-1184	8	1	CBL RD 100MM FEP	28480	5061-1184
W103	5061-1183	7	1	CBL BL 150MM FEP	28480	5061-1183
W104	5061-1182	6	1	CBL OR 150MM FEP	28480	5061-1182
W501	8120-3479	7	1	FRONT PANEL CABLE ASSEMBLY	28480	8120-3479
W502	5061-1165	5	1	ASSEMBLY-HPIL	28480	5061-1165
W701	8120-4586	9	1	JUMPER ASSEMBLY 22-AWG 1-COND	28480	8120-4586
X701	1200-0853	8	1	SOCKET-IC 16-CONT DIP DIP-SLDR	00779	2-640358-1
XF730	2110-0643	4	1	FUSEHOLDER-CLP-TYP 15A 250 V	28480	2110-0643
Y501	0410-1332	4	1	CRYSTAL-QUARTZ 6.003 MHZ HC-18/U-HLDR	81654	MSC-1256-1

Table 5-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3	03468-66503	2	1	PC ASSEMBLY-BATTERY CHARGER	28480	03468-66503
BT901	1420-0287	8	1	BATTERY, 6V, 3AH	28480	1420-0287
C901	0180-3908	5	1	CAPACITOR-FXD 2200UF+-20% 25VDC AL	56289	500D228M025GHSAD
C902	0160-0127	2	1	CAPACITOR-FXD 1UF +-20% 50VDC CER	04222	SR835E105MAA
C903-C904	0160-4571	8	5	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	SA105E104ZAA
C906	0180-0486	8	1	CAPACITOR-FXD 10UF+-10% 20VDC TA	28480	0180-0486
C907-C909	0160-4571	8	1	CAPACITOR-FXD .1UF +80-20% 50VDC CER	04222	SA105E104ZAA
C910	0180-1745	4	2	CAPACITOR-FXD 1.5UF+-10% 20VDC TA	56289	150D155X9020A2
C911	0160-4813	1	1	CAPACITOR-FXD 180PF +-5% 100VDC CER	04222	SA101A181JAA
C912	0180-1745	4	1	CAPACITOR-FXD 1.5UF+-10% 20VDC TA	56289	150D155X9020A2
CR901-CR907	1901-0743	1	7	DIODE-PWR RECT 1N4004 400V 1A DO-41	28480	1901-0743
CR908-CR911	1901-0050	3	6	DIODE-SWITCHING 80V 200MA 2NS DO-35	25403	BAV10 SELECTED
CR912-CR919	1901-1065	2	8	DIODE-PWR RECT 1N4936 400V 1A 200NS	30043	1N4936
CR920-CR921	1901-0050	3	1	DIODE-SWITCHING 80V 200MA 2NS DO-35	25403	BAV10 SELECTED
JM901-JM902	7175-0057	5	2	RESISTOR-ZERO OHMS SOLID TINNED COPPER	28480	7175-0057
Q901	1853-0305	8	1	TRANSISTOR PNP 2N5875 SI TO-3 PD=150W	04713	2N5875
Q902	1854-0472	2	2	TRANSISTOR NPN SI DARL PD=500MW	04713	MPS-A14
Q903	1854-0087	5	1	TRANSISTOR NPN SI PD=360MW FT=75MHZ	28480	1854-0087
Q904	1854-0756	5	1	TRANSISTOR NPN 2N6315 SI TO-66 PD=90W	04713	2N6315
Q905	1854-0472	2	1	TRANSISTOR NPN SI DARL PD=500MW	04713	MPS-A14
R901	0757-0449	6	1	RESISTOR 20K 1% .125W TF TC=0+-100	19701	SFR25H
R902	0757-0442	9	1	RESISTOR 10K 1% .125W TF TC=0+-100	19701	SFR25H
R903	0699-0032	9	1	RESISTOR 71.05K .25% .125W TF TC=0+-50	19701	5033R
R904	0698-6270	7	1	RESISTOR 125K .25% .125W TF TC=0+-50	91637	CMF-55-1, T-2
R905	0683-3335	8	2	RESISTOR 33K 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-33K
R906	0683-2715	6	2	RESISTOR 270 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-270
R907	0683-6835	9	2	RESISTOR 68K 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-68K
R908	0757-0465	6	2	RESISTOR 100K 1% .125W TF TC=0+-100	19701	SFR25H
R909	0698-3558	8	1	RESISTOR 4.02K 1% .125W TF TC=0+-100	19701	SFR25H
R910	0698-3440	7	1	RESISTOR 196 1% .125W TF TC=0+-100	19701	SFR25H
R911	0757-0467	8	1	RESISTOR 121K 1% .125W TF TC=0+-100	19701	SFR25H
R912	0757-0465	6	1	RESISTOR 100K 1% .125W TF TC=0+-100	19701	SFR25H
R913	0683-6835	9	1	RESISTOR 68K 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-68K
R914	0683-3055	9	1	RESISTOR 3M 5% .25W CF TC=0-900	28480	0683-3055
R915	0698-0077	0	1	RESISTOR 93.1K 1% .125W TF TC=0+-100	19701	SFR25H
R916	0698-3452	1	1	RESISTOR 147K 1% .125W TF TC=0+-100	19701	SFR25H
R918	0683-3335	8	1	RESISTOR 33K 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-33K
R919	0683-3325	6	1	RESISTOR 3.3K 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-3K3
R920	0683-2715	6	1	RESISTOR 270 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-270
R921	0683-2205	9	1	RESISTOR 22 5% .25W CF TC=0-400	19701	(CR-25) 1-4-5P-22E
R923	0698-3162	0	1	RESISTOR 46.4K 1% .125W TF TC=0+-100	19701	SFR25H
R924	0698-3228	9	1	RESISTOR 49.9K 1% .125W TF TC=0+-100	19701	SFR25H
R925	0683-1055	5	1	RESISTOR 1M 5% .25W CF TC=0-800	19701	(CR-25) 1-4-5P-1M
RT922	0837-0220	1	1	THERMISTOR ROD 10K-OHM TC=-3.83%/C-DEG	75263	AL1545-6240-73-S6
T901	9100-4206	9	1	TRANSFORMER-POWER PRIMARY INDUCTANCE	91637	IPE-1429-18
U901	1826-0544	0	1	IC V RGLTR-V-REF-FXD 2.5V 8-DIP-C PKG	34333	SG3503Y
U902	1826-0138	8	1	IC COMPARATOR GP QUAD 14-DIP-P PKG	27014	LM339N
U903-U904	1820-1745	3	2	IC GATE CMOS NOR QUAD 2-INP	04713	MC14001BCP
U905	1820-2466	7	1	IC TIMER CMOS	72799	1CM75551PA
W901	8120-3480	0	1	CABLE ASSEMBLY CABLE LUGGED SLIP ON	28480	8120-3480
W902	8120-3481	1	1	CABLE ASSEMBLY CABLE LUGGED SLIP ON	28480	8120-3481
W903	8120-3487	7	1	FLAT RIBBON ASSY 28-AWG 16-COND	28480	8120-3487
XF901	2110-0643	4	1	FUSEHOLDER-CLP-TYP 15A 250 V	28480	2110-0643

NOTE: A field retrofit kit (HP Part Number 03468-68701) is available that contains the parts necessary to convert a standard HP 3468A/B to battery operation.



Table 5-4. 3468A Mechanical and Miscellaneous Parts

Reference Designation	HP Part Number	C	D	Qty	Description
MP1	0370-0603	4	1		PUSHBUTTON (POWER SWITCH)
MP2	03468-60202	6	1		FRONT PANEL ASSEMBLY
MP3	2360-0137	0	4		SCREW (6-32 X 1.75 PH)
---	0900-0010	2	4		O-RING (ATTACHES TO MP3)
MP4	7121-2446	7	1		LABEL, INFO 3468A
MP5	5040-8058	5	1		HANDLE
MP6	03468-64401	5	1		BOTTOM SHELL
MP7	4040-1126	3	1		TOP SHELL
MP8	5040-8044	9	4		SPACER, SHELL
MP9	2360-0209	7	1		SCREW (6-32 X 1.0)
MP10	03468-00601	3	1		TOP SHIELD
MP11	2360-0117	6	4		SCREW (6-32 X .375)
MP12	4135-0415	2	1		EXTENDER SHAFT
MP13	0510-0585	9	4		PUSH-ON RETAINER
MP14	03468-00602	4	1		BOTTOM SHIELD
MP15	0624-0333	6	2		SCREW (TPG 4-20 .25-1N-LG)
MP16	5061-1166	6	1		LCD DISPLAY
MP17	0515-0226	5	2		SCREW (2.5 X 0.45 6MM-LG)
MP18	0515-0225	4	2		SCREW (3.5 X 0.6 10MM-LG)
MP19	03468-00111	0	1		BATTERY DECK
MP20	03468-01202	2	1		BATTERY COVER
MP21	5040-7223	4	2		PAD-NON SKID
MP22	7120-5370	0	2		LABEL, PULL/ROTATE
MP23	7121-2429	6	1		LABEL, LOGO 3468A
MP24	5061-1163	3	1		FUSE CAP
MP25	2110-0003	0	1		FUSE 3A 250V NTD
MP26	4320-0370	1	1		CONDUCTIVE ELASTOMER
MP27	7124-2083	4	1		LABEL, POWER LINE WARNING
MP28	7120-8607	2	1		LABEL, METRIC
W501	8120-3479	7	1		FRONT PANEL CABLE
W502	5061-1165	5	1		HP-IL CONNECTOR
W903	8120-3479	7	1		BATTERY CIRCUIT CABLE
Not Shown	8120-3547	0	1		TEST LEAD SET 1.2M LONG
Not Shown	03468-68701	6	1		BATTERY CHARGER (OPT. 001)

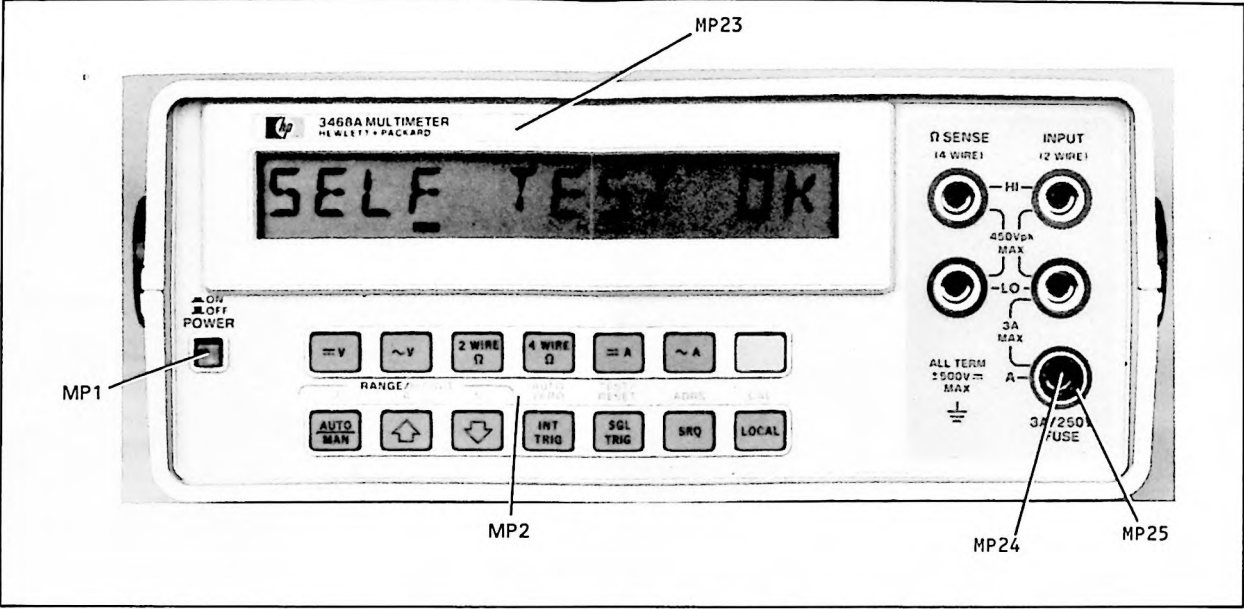


Figure 5-1. 3468A Front Panel View

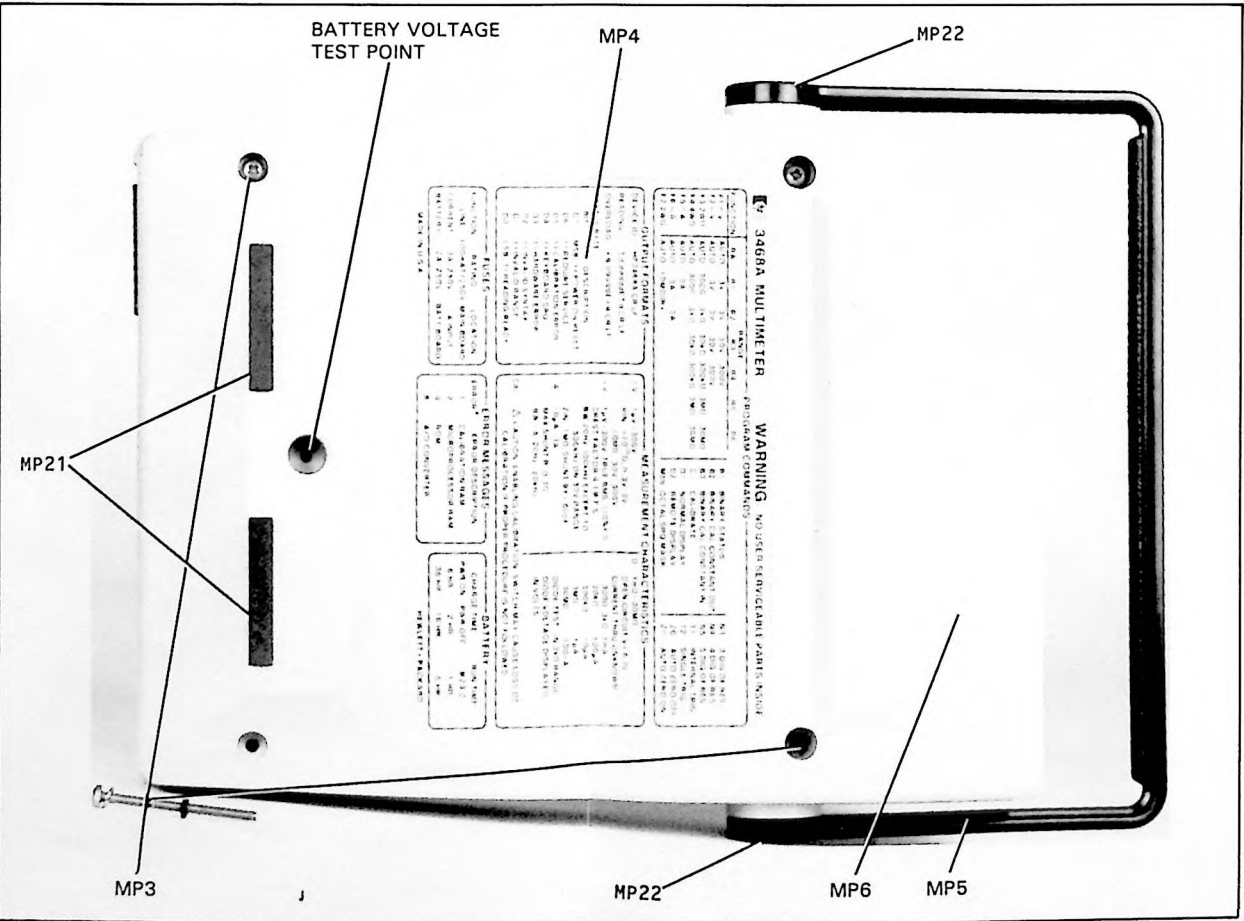


Figure 5-2. 3468A Bottom View

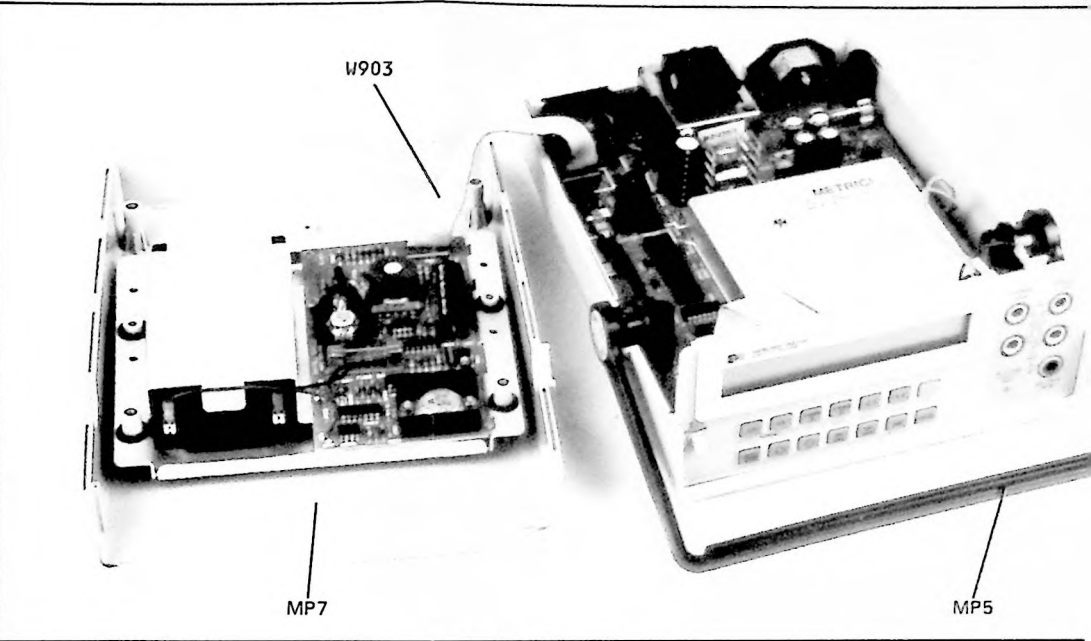


Figure 5-3. 3468A Inside View

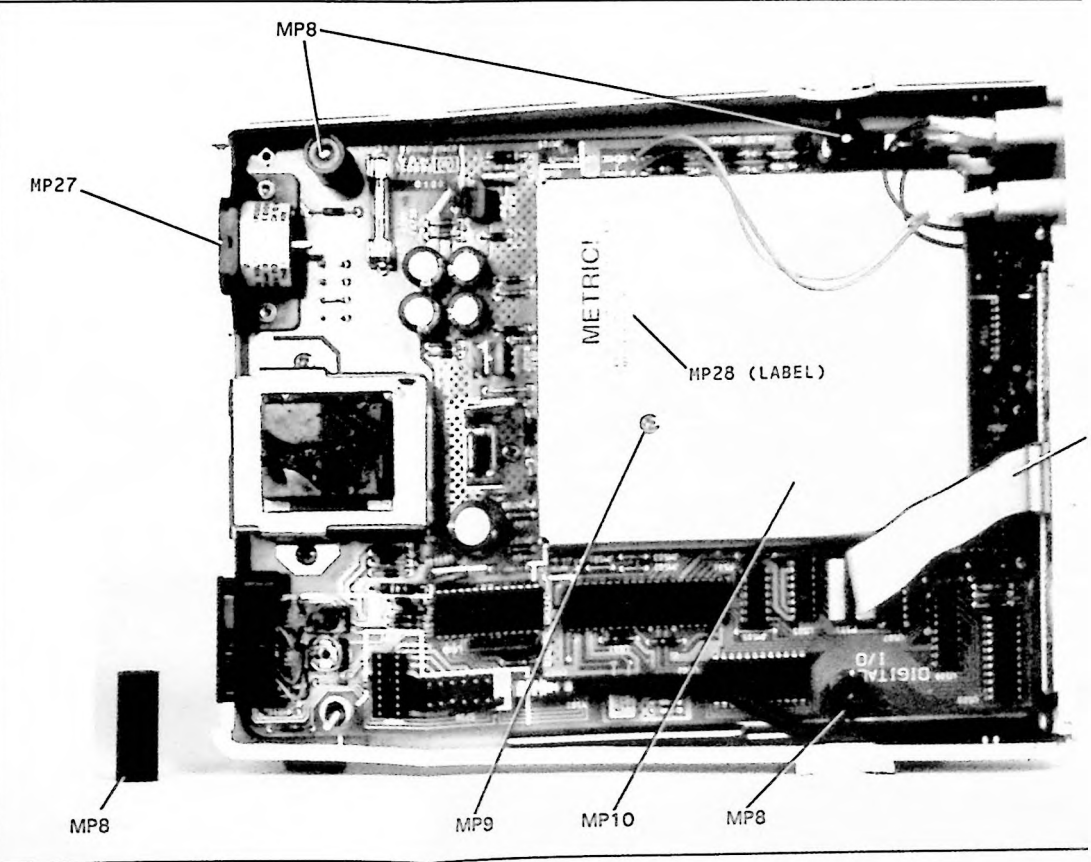
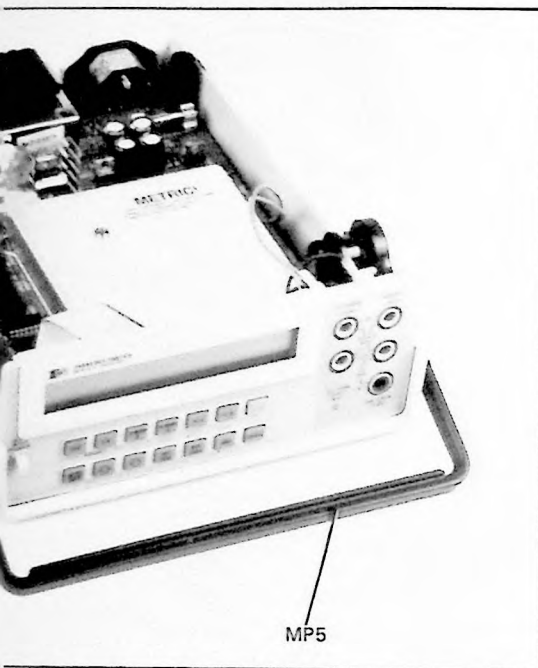
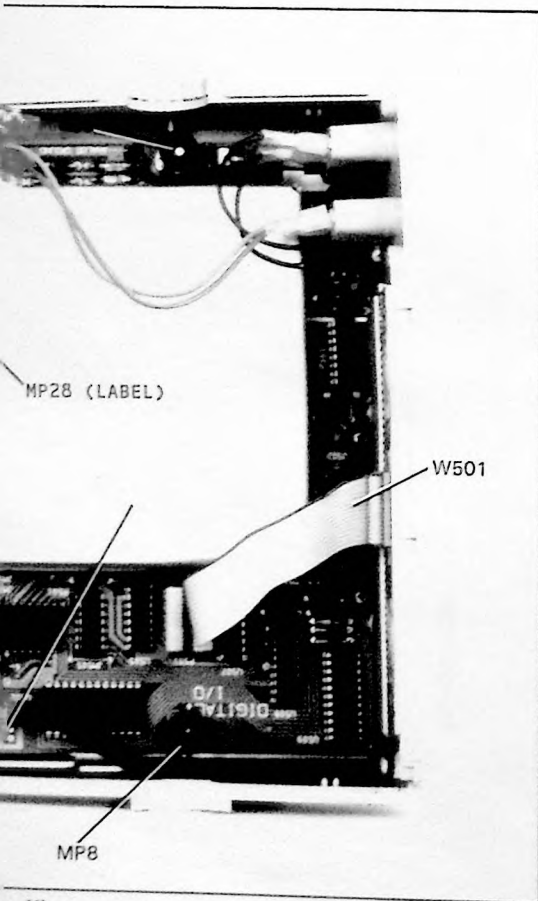


Figure 5-4. 3468A Top View





Side View



Top View

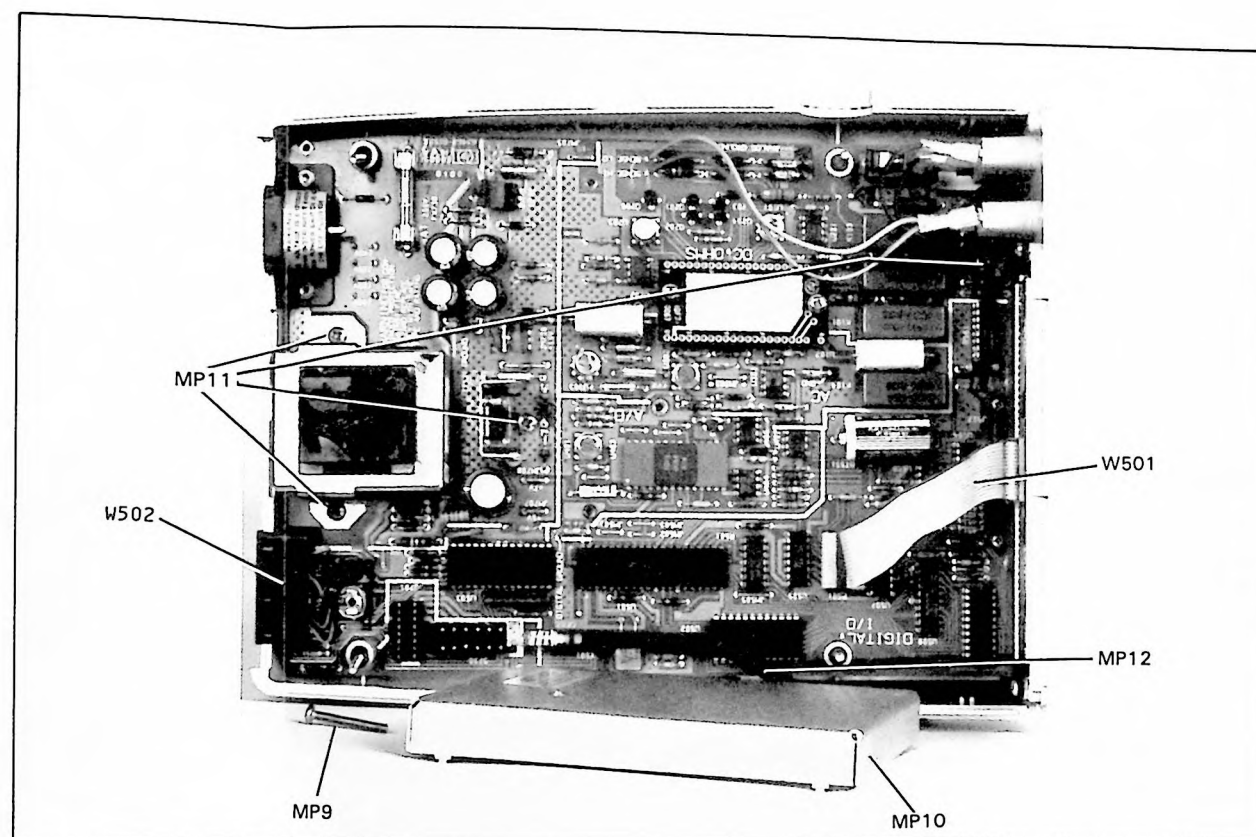


Figure 5-5. Top View with Inner Shield Removed (3468A)

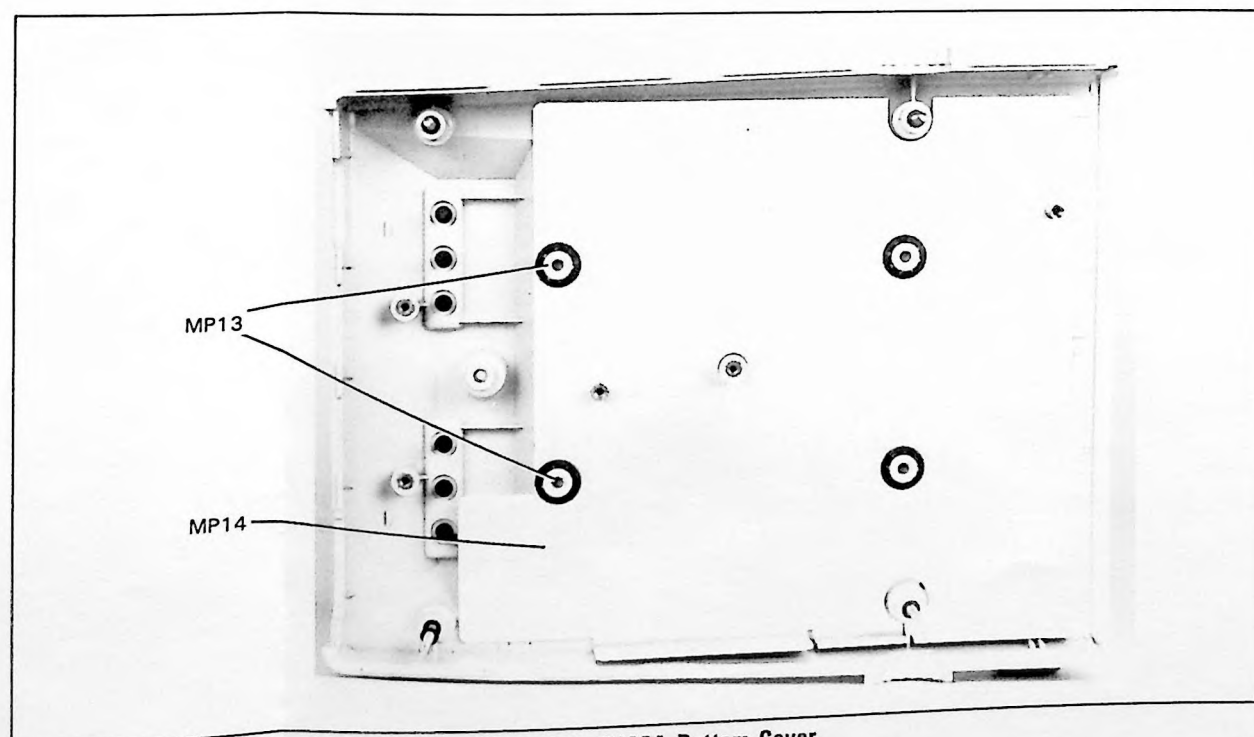


Figure 5-6. 3468A Bottom Cover

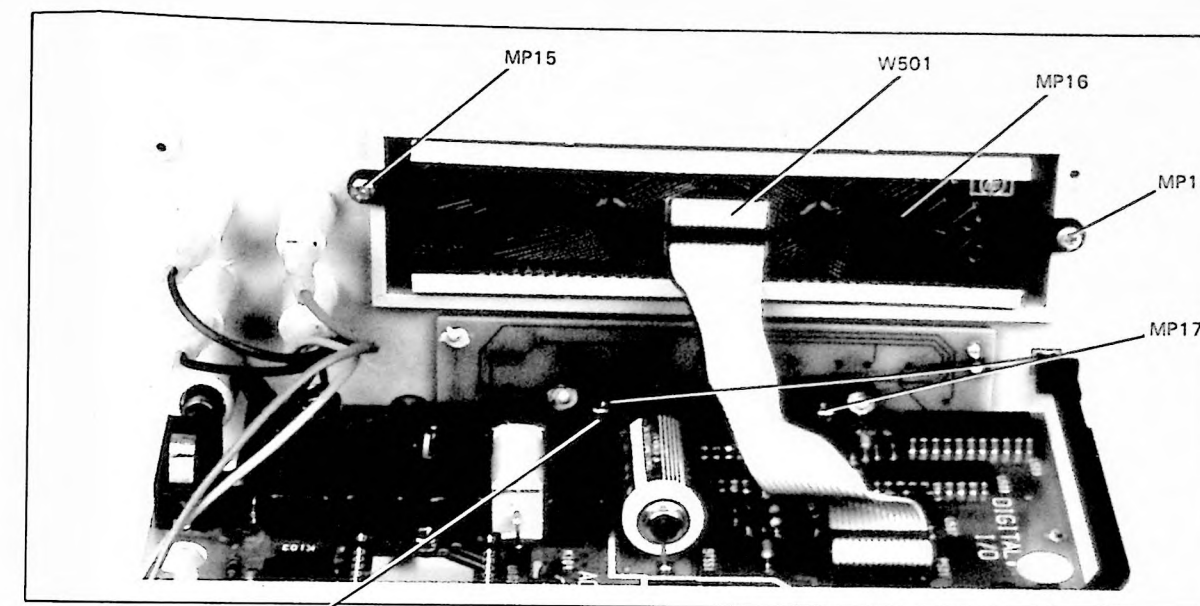


Figure 5-7. Front Panel Assembly View (3468A)

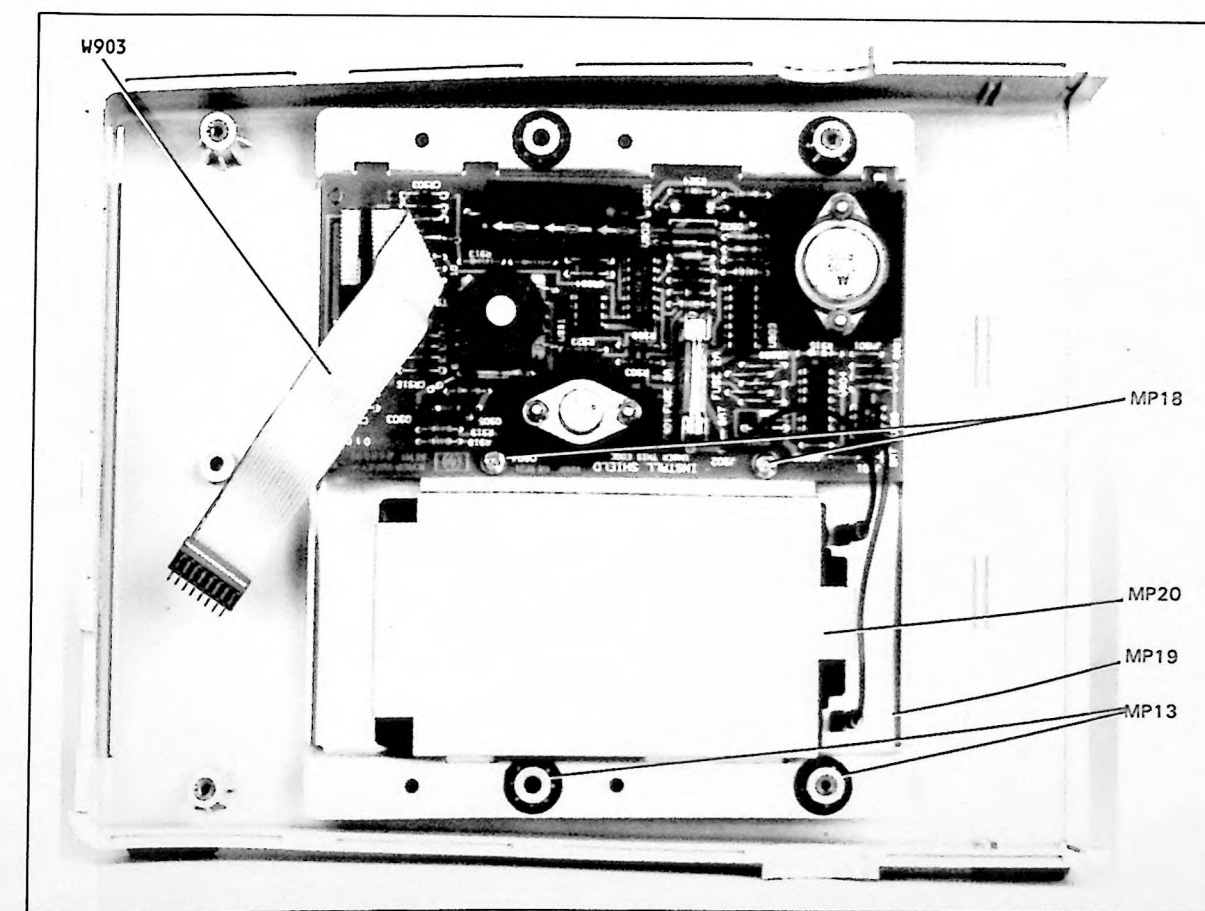


Figure 5-8. Top Cover View (with optional Battery Charger)

Table 5-5. 3468B Mechanical and Miscellaneous Parts					
Reference Designation	HP Part Number	C	D	Qty	Description
MP1	0370-0603	4	1		PUSHBUTTON (POWER SWITCH)
MP2	03468-60202	6	1		FRONT PANEL ASSEMBLY
MP3	0515-0637	2	4		SCREW (3.5 X 0.6 35MM-LG)
---	0900-0010	2	4		O-RING (ATTACHES TO MP3)
MP4	7121-4129	7	1		LABEL, BOTTOM COVER
MP5	1460-1345	5	2		TILT STAND
MP6	5040-7201	8	2		FOOT
MP7	7101-0639	4	1		BOTTOM SHELL
MP8	5040-7222	3	2		FOOT
MP9	7101-0640	7	1		TOP SHELL
MP10	4177-0236	3	4		SPACER TUBE
MP11	0515-0405	2	1		SCREW (3.5 X 0.6 25MM-LG)
MP12	03468-00601	3	1		SHIELD-TOP
MP13	0515-0225	4	4		SCREW (3.5 X 0.6 10MM-LG)
MP14	4135-0415	2	1		EXTENDER SHAFT
MP15	0510-0585	9	1		PUSH-ON RETAINER
MP16	1600-1185	9	2		RACK MOUNT FASTENER
MP17	03468-00612	6	1		BOTTOM SHIELD
MP18	0624-0333	6	2		SCREW (TPG 4-20 .25-IN-LG)
MP19	5061-1166	6	1		LCD DISPLAY
MP20	0515-0226	5	2		SCREW (2.5 X 0.45 6MM-LG)
MP21	0515-0212	9	4		SCREW (3.5 X 0.6 6MM-LG)
MP22	0515-0225	4	2		SCREW (3.5 X 0.6 10MM-LG)
MP23	03468-01202	2	1		BATTERY COVER
MP24	03468-00111	0	1		BATTERY DECK
MP25	5061-1163	3	1		FUSE CAP
MP26	2110-0003	0	1		FUSE 3A 250V NTD
MP27	7121-4128	6	1		LABEL, LOGO
MP28	4320-0370	1	1		CONDUCTIVE ELASTOMER
MP29	5180-0223	6	4		SIDE TRIM (FOAM STRIP)
MP30	7124-2083	4	1		LABEL, POWER LINE WARNING
MP31	7120-8607	2	1		LABEL, METRIC
W501	8120-3479	7	1		FRONT PANEL CABLE
W502	5061-1165	5	1		HP-IL CONNECTOR
W903	8120-3479	7	1		BATTERY CIRCUIT CABLE
Not Shown	8120-3547	0	1		TEST LEAD SET 1.2M LONG
Not Shown	03468-68701	6	1		BATTERY CHARGER (OPT. 001)

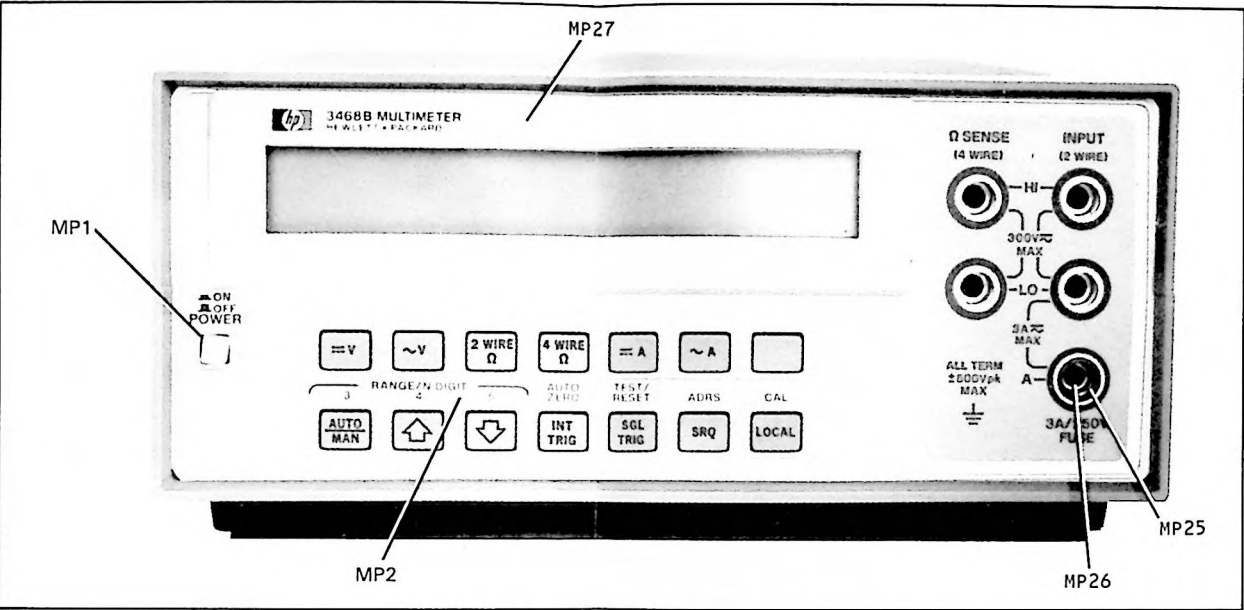


Figure 5-9. 3468B Front Panel View

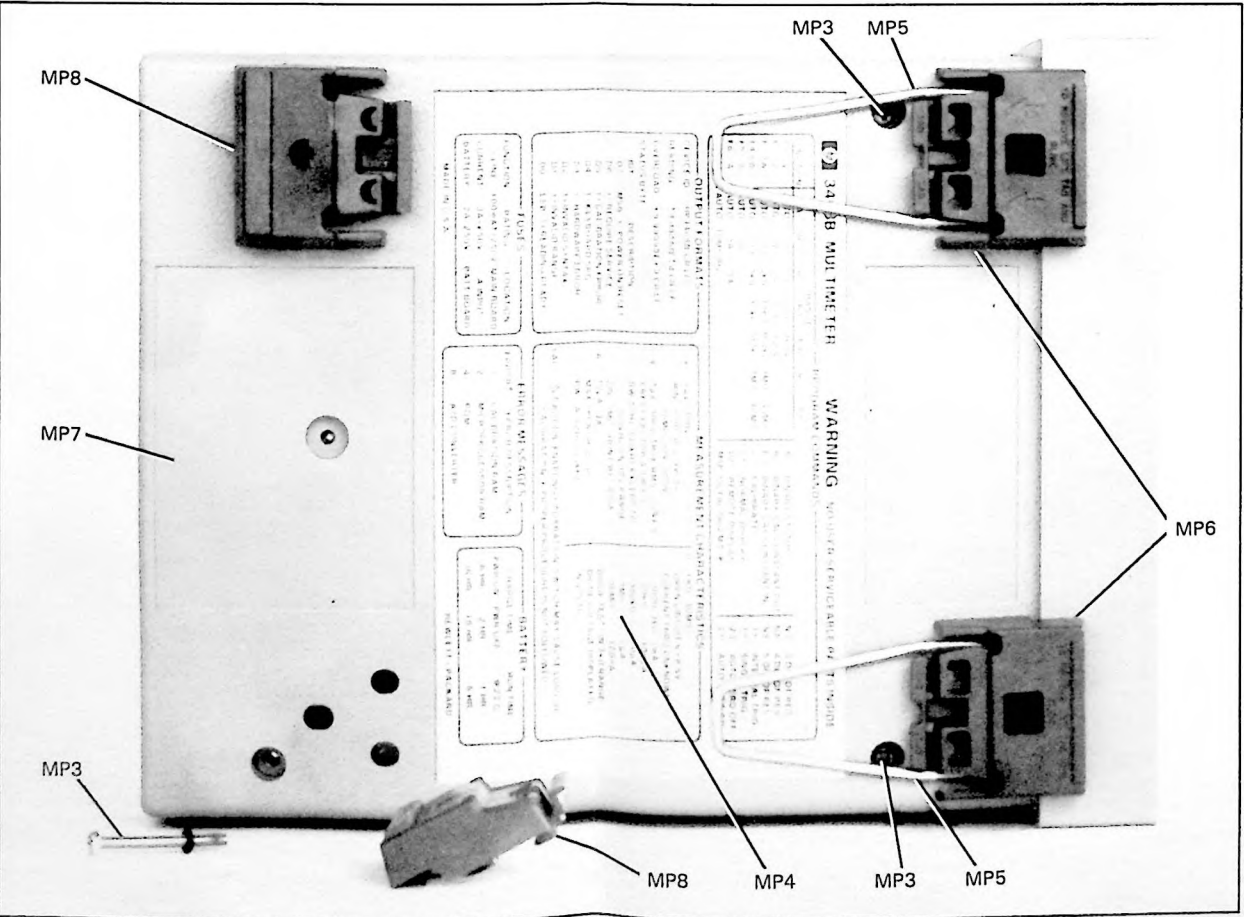


Figure 5-10. 3468B Bottom View

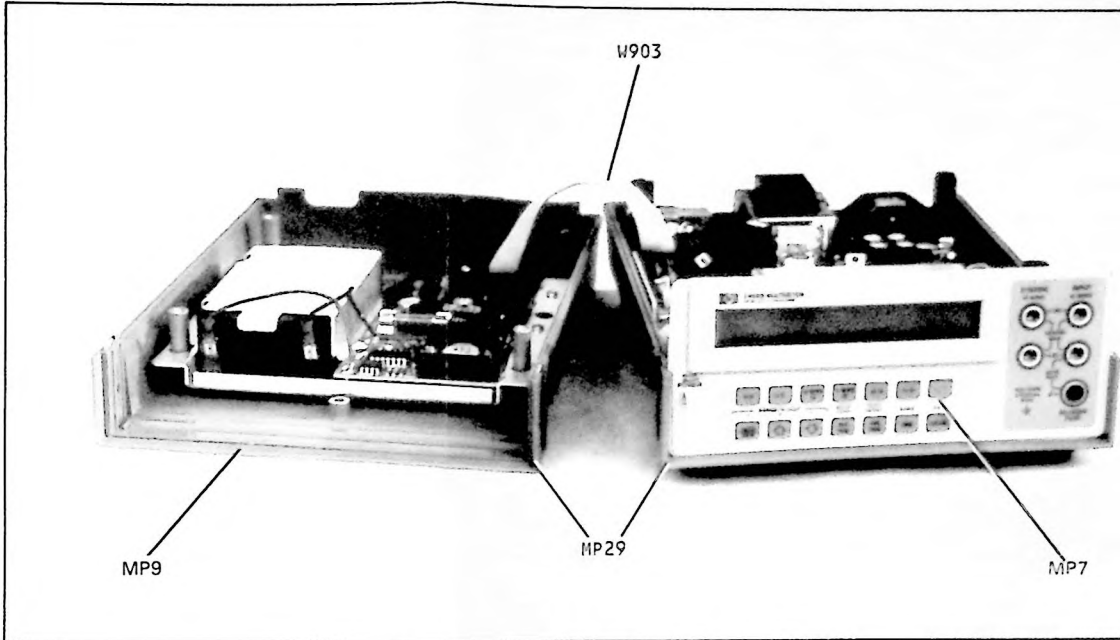


Figure 5-11. 3468B Inside View

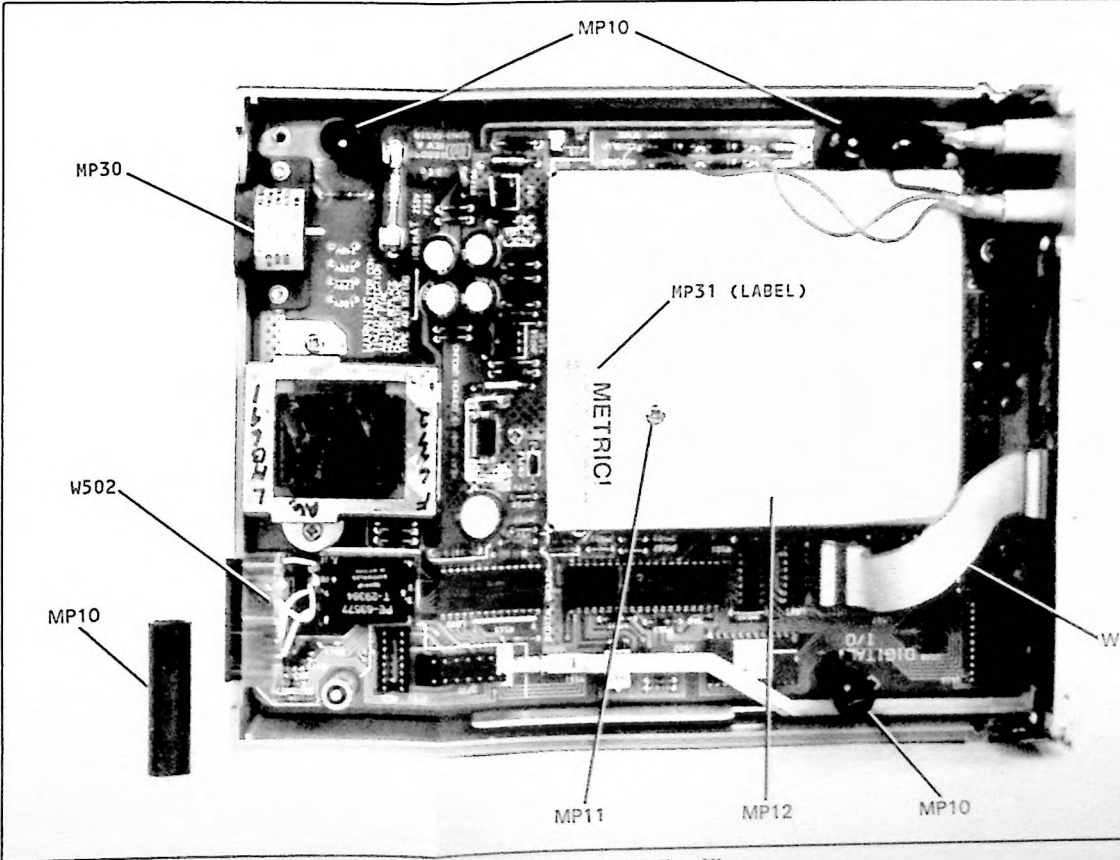


Figure 5-12. 3468B Top View



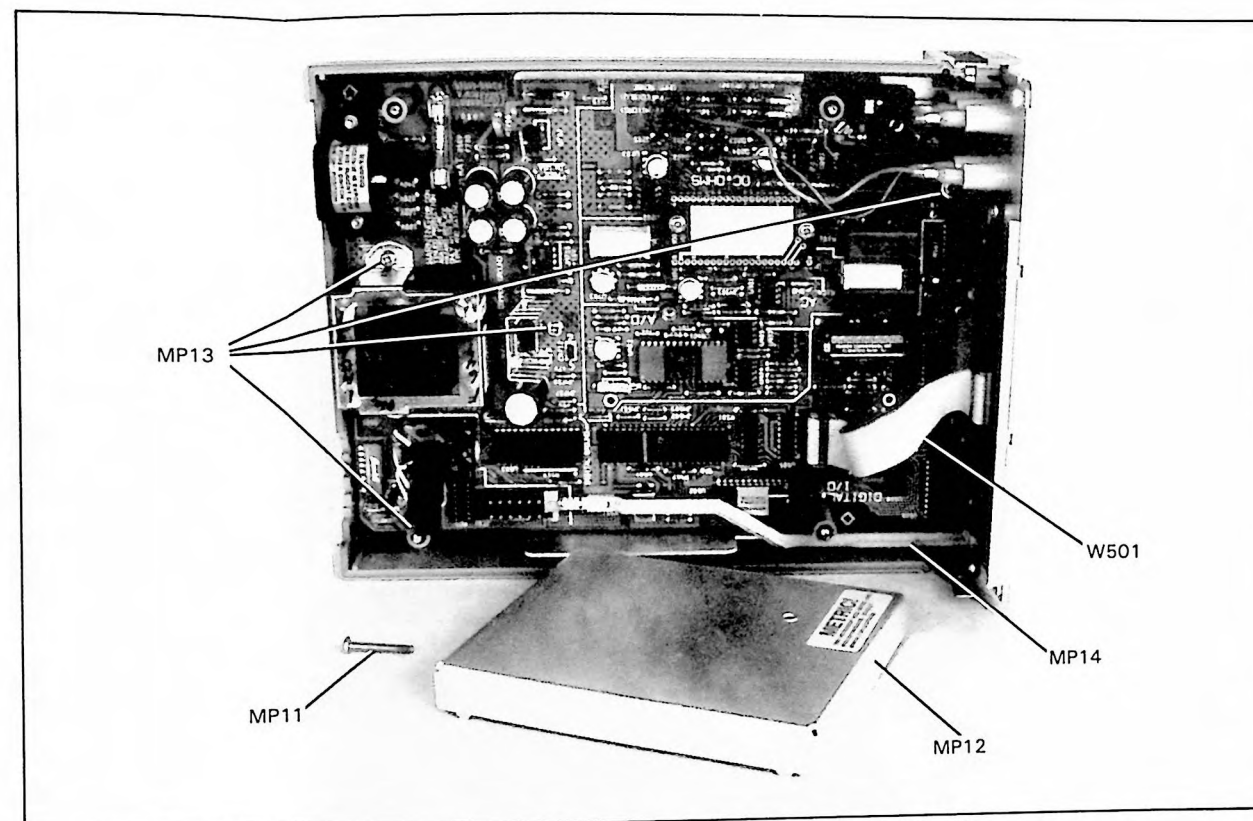
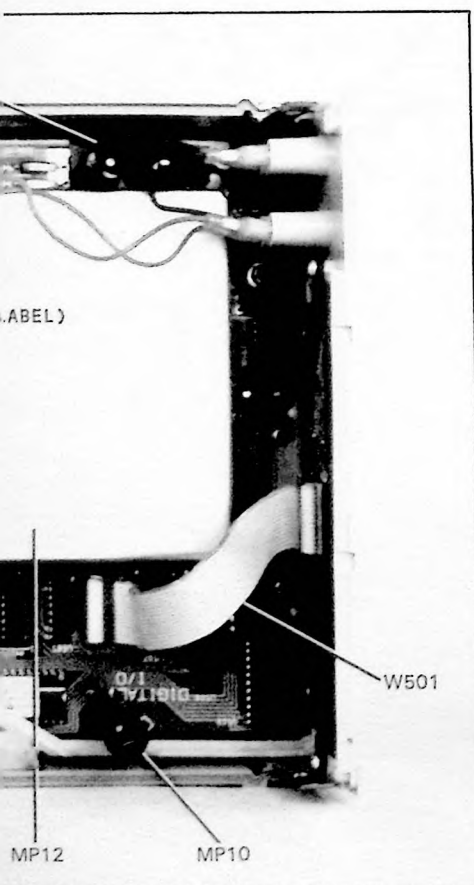


Figure 5-13. Top View with Inner Shield Removed (3468B)

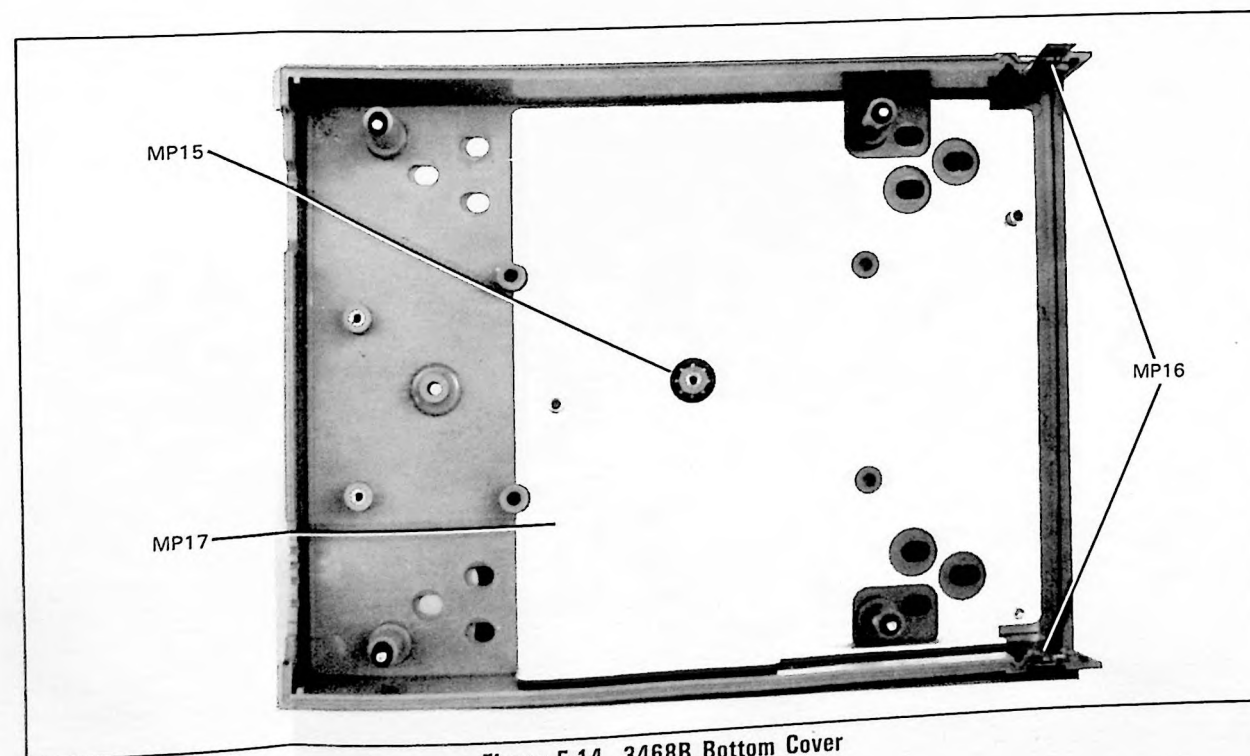


Figure 5-14. 3468B Bottom Cover

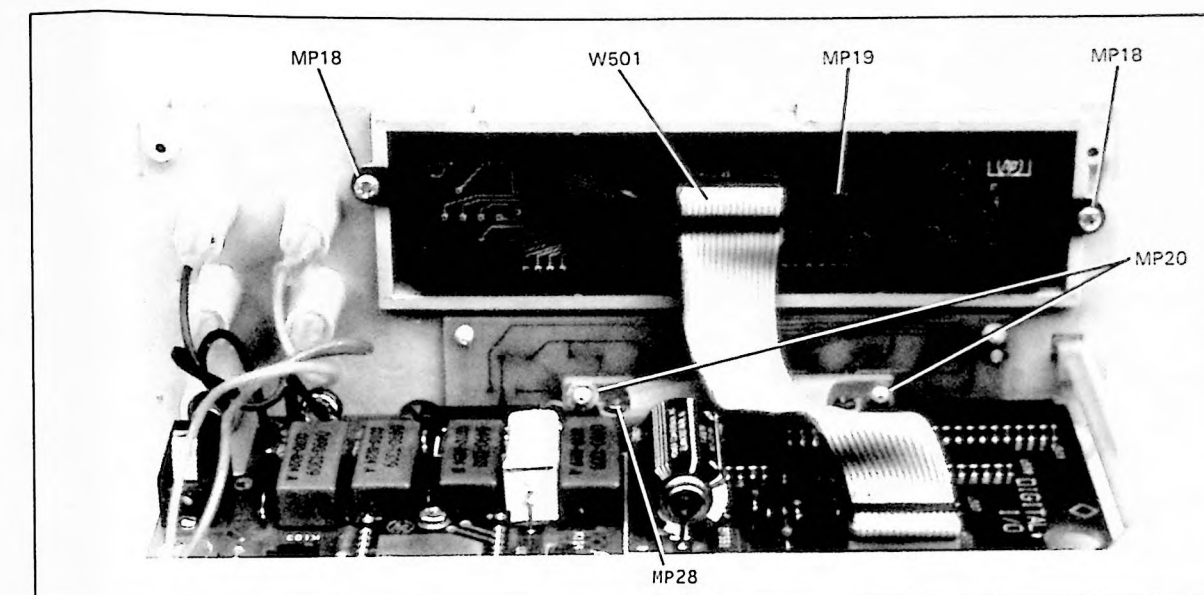


Figure 5-15. Front Panel Assembly View (3468B)

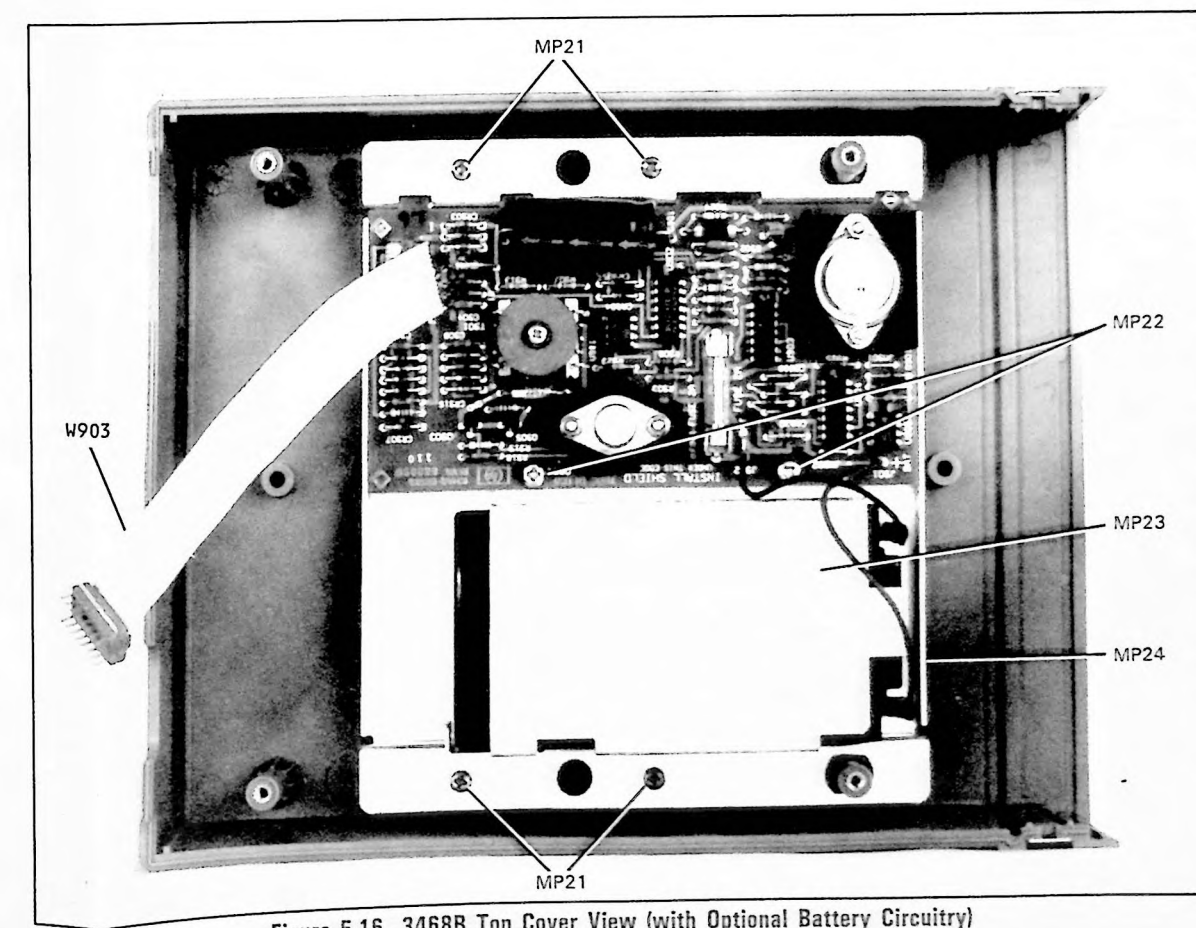


Figure 5-16. 3468B Top Cover View (with Optional Battery Circuitry)





## SECTION VI BACKDATING

### 6-1. INTRODUCTION

6-2. This section of the manual has information to adapt the manual to 3468A/B's with serial number prefixes and/or serial numbers below the ones shown on the title page. If the component values or part numbers in the 3468A/B differ from the ones shown on the schematics and Table 5-3, and are NOT listed in this section, use the component values and part numbers presently shown on the schematics and Table 5-3.

6-3. Refer to Table 6-1 to adapt this manual to instruments with serial numbers listed in the table. Make all the changes in sequence, as shown opposite the 3468A/B's serial number listing. If your instrument's serial number is not listed in the table, the changes may be documented on a yellow MANUAL CHANGES supplement.

**Table 6-1. Manual Changes**

Instrument Serial Number	Make Manual Changes
3468A: 2137A03600 and Below	1,2
3468A: 2137A05980 and Below	2

### 6-4. MANUAL CHANGES

#### 6-5. Change #1 (3468A Serial No. 2137A03600 and Below)

6-6. The following changes apply to 3468As that have the older version of the A1 Assembly (-hp- Part Number: 03468-66501). If the A1 Assembly needs to be replaced, replace it with the new version (-hp- Part Number: 03468-66510). If this is done, the following Change #1 information does not apply.

6-7. Table 7-D-1 Changes. Replace Table 7-D-1 with Table 6-2.

**Table 6-2. Change #1 in Table 7-D-1**

Switch Number	Switch State	
	Open or up (0)	Closed or Down (1)
1	Talk Only Mode	Normal
2	Not Used	Not Used
3	Power On SRQ	Normal
4	Not Used	Not Used
5	50Hz	60Hz
6	Normal	SA1*
7	Normal	SA2*
8	Normal	Enable Calibration

\*SA1 and SA2 switches must not be closed at the same time.  
SA2 causes the display to go blank.

6-8. Paragraph 7-D-23-c Changes. Change step c to the following:

c. On S501, set all switches down (closed), except for switches 7 and 8 which should be up (open). For 50Hz operation, also set switch 5 up.

6-9. Paragraph 7-D-27-b Changes. Change step b to the following:

b. On S501, set all switches down (closed), except for switches 7 and 8 which should be up (open). For 50Hz operation, also set switch 5 up.

6-10. Paragraph 7-D-32-a. Change step a to the following:

a. Make sure S501 is setup as given in paragraph 7-D-27 step b.

6-11. Paragraph 7-D-32-e Changes. Change all "T503" references in step e to "T501 and T502".

6-12. Change #2 (3468A Serial No. 2137A05980 and Below)

6-13. Paragraph 7-D-23-f Changes. Change the signature in step f from "AA2F" to "F5FH".

6-14. Paragraph 7-D-23-g Changes. Change the signatures in step g to the following:

Pin	Signature
W501(4)	0000
W501(8)	F5FH
W501(9)	1CC4
W501(10)	2367
W501(11)	2UA8
W501(12)	F119
W501(14)	9FU6
W501(15)	P5C0

6-15. Table 7-D-3 Changes. Change the table to the one shown in Table 6-3.

6-16. Paragraph 7-D-28-c Changes. Change the signature in step c from "F551" to "3P2P".

6-17. Paragraph 7-D-29-b Changes. Change the signature in step b from "AA2F" to "F5FH".



**6-18. Table 7-D-4 Changes.** Replace Table 7-D-4 with Table 6-4

**6-19. Paragraph 7-D-30-c Changes.** Change the signatures in step c from "AA2F" and "310A" to "HH47" and "8H28", respectively. Also change the front panel keys signatures, located after step c, to the signatures shown in Figure 6-1.

**Table 6-3. Change #2 in Table 7-D-3**

35F0	1	24	3P2P	
7FAF	2	23	C82P	+ 5V: 3P2P
F5PU	3	22	2AC1	Gnd: 0000
1PFP	4	21	0000	
835P	5	20	0000	
95U5	6	19	7CA0	
76U4	7	18	C550	
FC69	8	17	4P78 or 47C2	
99F4	9	16	UUAU	
OU6C	10	15	20HH	
6919	11	14	FUUA	
	12	13	2958	

**Table 6-4. Change #2 in Table 7-D-4**

0000	1	40	F5FH	
0000	2	39	RANDOM	
0000	3	38	F5FH	
F5FH	4	37	0000	
F5FH	5	36	2UA8	
F5FH	6	35	1CC4	
F5FH	7	34	0000	
F5FH	8	33	F5FH	
F5FH	9	32	F5FH	
F5FH	10	U501	31	0000
0000	11	μ	30	F5FH
F5FH	12		29	F5FH
F5FH	13		28	F5FH
F5FH	14		27	HH47
F5FH	15		26	F5FH
F5FH	16		25	F5FH
F5FH	17		24	77CA
F5FH	18		23	FC60
F5FH	19		22	8233
0000	20		21	0899

2UA8	1	14	F5FH	
1CC4	2	13	F5FH	
0000	3	U501	12	77CA
0000	4	RESISTOR	11	FC60
F5FH	5		10	8233
F5FH	6		9	0899
F5FH	7		8	F5FH

F5FH	1	16	F5FH	
F5FH	2	15	F5CO	
0000	3	14	9FU6	
0000	4	W501	13	H23H
0000	5	DISPLAY	12	F119
0000	6	CABLE	11	2UA8
0000	7		10	2367
F5FH	8		9	1CC4

HH47	1		
F5FH	2		
F5FH	3		
F5FH	4		
F83A	5	J501	
95A2	6		
H74P	7		
4U1C	8		

CONNECTOR TO KEYBOARD

DAC				PF23	1	24	F5FH	
R401	95A2			7FAF	2	23	0899	
R402	H74P			3POF	3	22	8233	
R403	4U1C			P52H	4	21	0000	
R404	2367			835P	5	20	F5FH	
R405	F119			C839	6	U502	19	FC60
R406	9FU6			5A3C	7	ROM	18	77CA
				9UA5	8		17	F5FH
				F5FH	D9		16	F5FH
				F5FH	10		15	F5FH
				F5FH	11		14	F5FH
				0000	12		13	F5FH

7FAF	1	22	F5FH	
3POF	2	21	FP23	
P52H	3	20	F5FH	
835P	4	19	9FU6	
C839	5	U509	18	F5FH
5A3C	6	RAM	17	F5FH
9UA5	7		16	F5FH
0000	8		15	F5FH
F5FH	9		14	F5FH
F5FH	10		13	F5FH
F5FH	11		12	F5FH

U501 Pin#	Press Button	Change From	Signature To
27	≡ V	H47	8H28
27	AUTO/MAN	HH47	FUFA
27	≡ A	HH47	H0C0
27	SGL/TRIG	HH47	4U1C
28	~V	F5FH	95A2
28	UP RANGE	F5FH	H74P
28	~A	F5FH	F83A
28	SRQ	F5FH	4U1C
29	2 WIRE	F5FH	95A2
29	DOWN RANGE	F5FH	H74P
29	SHIFT	F5FH	F83A
29	LOCAL	F5FH	4U1C
30	4 WIRE	F5FH	95A2
30	INT/TRIG	F5FH	H747

**Figure 6-1. Front Panel Keys Signature For Change #2**

**6-20. Paragraph 7-D-32-d Changes.** Change the signature in step d from "0854" to "U085".





## SECTION VII

### SERVICE

#### 7-1. INTRODUCTION

7-2. This section of the manual has information on how to troubleshoot and repair the 3468A/B multimeter with the information given in Service Groups. Preliminary troubleshooting procedures to select an appropriate group is also given in paragraph 7-24. It is recommended to use the procedures first, before going to a service group. Section VII also has the 3468A/B's complete Theory of Operation (in Service Group F), the complete Schematics (in Service Group G), and the necessary safety considerations. The section is separated as follows:

#### NOTE

*The 3468A/B's Theory of Operation is in Service Group F (next to the last group).*

- a. Safety Considerations - paragraph 7-3.
- b. Recommended Test Equipment - paragraph 7-8.
- c. Miscellaneous Information - paragraph 7-10.
  - 1. Instrument Disassembly (PC Board Replacement) - see Section V.
  - 2. Fuse Replacement - paragraph 7-13.
- d. Troubleshooting - paragraph 7-15.
  - 1. Introduction - paragraph 7-16.
  - 2. 3468A/B Self-Test - paragraph 7-18.
  - 3. Service Group Selection - paragraph 7-24.

#### 7-3. SAFETY CONSIDERATIONS

7-4. The 3468A/B has been designed with international safety standards. To maintain these standards, the cautions, warnings, and other safety related information in this manual must be followed when servicing the instrument. Servicing should only be done by qualified service personnel.

7-5. Calibration, maintenance, or repair of the instrument with covers removed while any power or voltage is applied, should be avoided as much as possible. If any work is done while power and/or voltage is applied, the work should be carried out by a skilled person who is aware of the hazards involved.

#### WARNING

*Any interruptions of the protective grounding conductor (inside or outside the instrument) or disconnections of the protective earth terminal can make the instrument dangerous. Intentional interruption of the protective grounding conductor is strictly prohibited.*

7-6. It is possible for capacitors inside the instrument to remain charged when the instrument has been turned off or its power source disconnected.

7-7. Make sure that only the recommended fuse type (fast blow, correct current rating, etc.) is used for replacement. The use of repaired fuses and the short-circuiting of fuse holders must be avoided.

#### WARNING

*The service information given in this manual is normally used with the instrument's protective covers removed and with power applied. Voltage or signals at many points may, if contacted, result in personal injury.*

#### 7-8. RECOMMENDED TEST EQUIPMENT

7-9. The recommended test equipment is listed in Table 4-2 in Section IV of this manual.

#### 7-10. MISCELLANEOUS INFORMATION

##### 7-11. Instrument Disassembly (PC Board Replacement)

7-12. To replace the 3468A/B's main printed circuit board, the instrument must be completely disassembled. The procedure to disassemble the instrument is in Section V (Replaceable Parts) of this manual, which also has a procedure to replace the battery option board.

##### 7-13. Fuse Replacement

7-14. The 3468A/B has two fuses plus an additional fuse for the battery option. One fuse is the main power fuse, another fuse is to protect the instrument in the DC and AC Current Functions, and the battery fuse is to protect the Battery Charger Circuitry. The main power fuse and the battery option fuse can only be replaced by remov-

ing the 3468A/B's top cover. Go to Section V of this manual for the disassembly procedure. The Amps Fuse is located inside the 3468A/B's A (Amps) terminal (on the front panel). To replace the fuse, first remove any cables connected to the A terminal and then turn the instrument off. Use the side slots on the A terminal to rotate the terminal counterclockwise. The terminal and fuse will then protrude from the front panel. Remove the terminal and fuse, and replace the fuse with a 3A at 250V fast blow fuse (-hp- Part No. 2110-0003). Return the terminal and fuse to the front panel.

## 7-15. TROUBLESHOOTING



*The instrument contains CMOS Integrated Circuits which are susceptible to failure due to static discharge. It is especially important that grounded tools and wrist straps be used when handling or troubleshooting these components.*

## 7-16. Introduction

7-17. The following paragraphs and Service Groups have troubleshooting information and procedures for the -hp- Model 3468A/B Digital Multimeter. Before troubleshooting and repairing the 3468A/B, make sure the failure is in the instrument rather than from any external connections. Also make sure the instrument is calibrated.

## 7-18. 3468A/B Self-Test

7-19. The 3468A/B Self-Test is designed to make sure that most of the instrument's internal logic circuitry is operational. The test is selected when the 3468A/B is first turned on or by pressing the blue Shift button and then the SGL/TRIG (TEST/RESET) button. The following paragraphs have the Self-Test Failures and some troubleshooting information.

**7-20. Calibration RAM Error (ERROR 1).** If this test fails, an attempt made to calibrate the RAM was unsuccessful. First try to calibrate the 3468A/B. If the failure is still noted, go to Service Group D, paragraph 7-D-13 to check the CMOS RAM.

**7-21. RAM Error (ERROR 2).** This test shows that the Main Controller's (U501) RAM has failed its internal self test. The failure is normally caused by a defective U501. To make sure U501 is the cause, go to Service Group D, paragraph 7-D-13, for further troubleshooting.

**7-22. ROM Error (ERROR 4).** This indicates that the 3468A/B has failed its internal ROM self test. The Control ROM (U502) is the most likely cause. Go to Service Group D, paragraph 7-D-24, for further troubleshooting.

**7-23. A/D Converter Error (ERROR 8).** This shows that the A/D Converter has failed its internal self test. Go to Service Group D, paragraph 7-D-33 (A/D Converter Troubleshooting) for troubleshooting.

## 7-24. Service Group Selection

Table 7-1. 3468A/B Service Groups

Service Group	Title
A	DC Volts and DC Current Troubleshooting
B	AC Volts and AC Current Troubleshooting
C	Ohms Troubleshooting
D	A/D Converter and Logic Troubleshooting
E	Miscellaneous Troubleshooting (Battery, etc.)
F	Theory of Operation
G	Schematics

7-25. The Service Groups have the Troubleshooting Information, Theory of Operation, and Schematics for the 3468A/B. Service Group F has the Theory of Operation and Service Group G has the Schematics. The rest of the groups have troubleshooting information.

7-26. The correct Service Group is selected according to failure. Once the failure has been determined, go to the recommended group. The following paragraphs lists possible failures, general troubleshooting information, and corresponding Service Group(s). The Service Groups are also listed in Table 7-1.

**7-27. DC Volts and DC Current Failure (Service Group A).** Typical DC Volts and DC Current Failures are Overload, Inaccurate, Constant Zero, Floating, or Noisy Readings. Troubleshooting information for these failures is in Service Group A. The following explains the failures.

a. **Overload.** An overload is caused when the reading taken by the instrument appears to be larger than the input actually is. This can be caused by a saturated DC/Ohms Input Amplifier or by the A/D Converter.

b. **Inaccurate Readings.** Inaccurate readings are normally caused when the measurement circuitry is not linear. This is because the 3468A/B is calibrated using zero and full scale inputs. Therefore, the full scale and zero readings must be good, but any other reading can be inaccurate.

c. **Constant Zero Reading.** A constant zero reading is normally caused when either the input to the DC/Ohms Input Amplifier or the input to the A/D Converter is shorted to ground (common). It can also be caused if no runup is done by the A/D Converter.

d. **Floating Reading.** A floating reading is when the 3468A/B displays a certain reading (with no input applied) which does not change, after an input is applied to the multimeter. This can be caused by the A/D Converter and if there is an open in the Input Circuitry.



e. **Noisy Readings.** Noisy readings can be caused by the Input Circuitry and A/D Converter.

**7-28. AC Volts and AC Current Failures (Service Group B).** AC Volts and AC Current Failures can be Overload, Inaccurate, Floating, or Noisy Readings. Troubleshooting information for these failures is in Service Group B. Before going to the service group, check and make sure the DC Volts and DC Current Function is operating correctly. The DC Volts and DC Current failures are explained in paragraph 7-27. The following explains the AC Volts and AC Current Failures.

a. **Overload.** An overload is caused when the reading taken by the instrument appears to be larger than the input actually is. This can be caused by a saturated AC to DC Converter or the A/D Converter.

b. **Inaccurate Readings.** Inaccurate readings are normally caused when the AC to DC Converter has poor frequency response.

c. **Floating Reading.** A floating reading is when the 3468A/B displays a certain reading (with no input applied) which does not change, after an input is applied to the multimeter. This can be caused if there is an open circuit in the AC to DC Converter or A/D Converter.

d. **Noisy Readings.** Noisy readings can be caused by the amplifiers and the RMS Converter in the AC to DC Converter.

**7-29. Ohms Failures (Service Group C).** Typical Ohms Failures can be Overload, Inaccurate, Floating, or Noisy Readings. Troubleshooting information for these failures is in Service Group C. Before going to the service group, check and make sure the DC Volts and DC Current Functions are operating correctly. The DC Volts and DC Current failures are explained in paragraph 7-27. The Ohms Failures are explained as follows:

a. **Overload.** An overload is caused when the reading taken by the instrument appears to be larger than the input actually is. This can be caused if the ohms current is too large. Since the DC/Ohms Input Amplifier or the A/D Converter can also cause an overload, make sure the DC Volts Function is operating correctly (go to paragraph 7-27, if the function fails).

b. **Inaccurate Readings.** Inaccurate ohms readings can be caused if the ohms current changes value under different loads. Inaccuracy can also be caused if the measurement circuitry is not linear. Make sure the DC Volts Function is operating correctly (go to paragraph 7-27, if the function fails).

c. **Constant Zero Reading.** A constant zero reading is normally caused when the Ohms Current Source does not supply any ohms current. The failure can also be caused when either the input to the DC/Ohms Input Amplifier or the input to the A/D Converter is shorted to ground

(common). Make sure the DC Volts Function is operating correctly (go to paragraph 7-27, if the function fails).

d. **Floating Reading.** A floating reading is when the 3468A/B displays a certain reading (with no input applied) which does not change, after an input is applied to the multimeter. This can also be caused by the A/D Converter and the Input Circuitry. Since this is not an ohms failure, make sure the DC Volts Function is operating correctly (go to paragraph 7-27, if the function fails).

e. **Noisy Readings.** Noisy readings can be caused by a noisy ohms current.

**7-30. Logic Failures (Service Group D).** Logic Failures consists of Turn-On, Display, Keyboard, Control ROM, Calibration RAM (CMOS RAM), Processor RAM, and HP-IL Failures. Go to Service Group D, paragraph 7-D-12, if any of the failures are detected. The following explains the failures.

a. **Turn-On Failure.** A Turn-On Failure is when the 3468A/B's Keyboard, Display, and HP-IB is dead (i.e., the 3468A/B is completely inoperative). This is most likely caused by the Main Controller (U501) and associated circuitry.

b. **Inoperative Display.** An Inoperative Display is when part or all of the 3468A/B's display is inoperative. This can be caused by the display itself or the Main Controller Circuitry.

c. **Inoperative Keyboard.** An Inoperative Keyboard is when part or all of the 3468A/B's keyboard is inoperative. This can be caused by the keyboard itself or the Main Controller Circuitry.

d. **Control ROM Failure.** A failure caused by the Control ROM normally shows up as "ERROR 4" (after the 3468A/B's Self-Test). The ROM (U502) itself can be the cause in addition to the Main Controller (U501) and latch U508. A defective ROM can also show up as a Turn-On Failure.

e. **Processor RAM Failure.** This failure shows up as "ERROR 2" after the 3468A/B's Self-Test routine. It shows that the Main Controller's internal RAM has failed its self-test.

f. **Calibration RAM (CMOS RAM) Failure.** This failure can show up as a "ERROR 1" after the 3468A/B's Self-Test routine. The RAM (U509) itself can be the cause or the Main Controller Circuitry.

g. **HP-IL (Remote) Failure.** This failure is most likely caused by the HP-IL Chip (U503), but can also be caused by other circuitry in the Chassis Common Logic Circuitry.



**7-31. A/D Converter Failures (Service Group D).** The A/D Converter Failures are normally caused by the A/D Converter itself or the Main Controller (U501). Go to Service Group D, paragraph 7-D-33 for troubleshooting. The following explains the failures.

a. **Overload, Constant Zero, Floating, or Noisy Readings.** Any one of these failures can be caused by the A/D Converter or the 3468A/B's Input Circuitry (Input Switching or DC/Ohms Input Amplifier). Since both circuitry can cause a failure, a procedure to isolate the circuitry is in both Service Group D and Group A. For a definition of the failures, go to paragraph 7-27 (DC Volts Failures).

b. **A/D Converter Fails.** This failure can be caused by the A/D Converter or the Main Controller. It shows up as "ERROR 8", after a Self-Test routine.

c. **Input Hybrid (U102) Failure.** Since the Input Hybrid receives its set-up information from the Main Controller, the controller can cause the hybrid to fail.

**7-32. Miscellaneous Troubleshooting (Service Group E).** Service Group E has some information on how to troubleshoot the 3468A/B's power supplies, Reference Circuitry, and the optional Battery Charger Circuitry. The Battery Charger Circuitry fails if the 3468A/B is unable to operate on its internal battery (i.e., the ac power source is disconnected).

# SERVICE GROUP A

## DC VOLTS AND DC CURRENT TROUBLESHOOTING

### Service Group A Contents

Title	Paragraph
Introduction.....	7-A-1
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Overload, Constant Zero, Floating, or Noisy Readings on Some Ranges.....	7-A-11
Inaccurate Readings on All Ranges.....	7-A-17
Protection Circuitry Troubleshooting.....	7-A-19
Input Circuitry Troubleshooting.....	7-A-21
Overload Readings on All Ranges.....	7-A-23
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Floating Readings on All Ranges.....	7-A-27
Noisy Readings on All Ranges.....	7-A-29
DC Current Troubleshooting.....	7-A-31

### 7-A-1. INTRODUCTION

7-A-2. This Service Group has the DC Volts and DC Current troubleshooting information for the 3468A/B. The Service Group is symptoms oriented (i.e., what fails) with two different levels of troubleshooting. The first level determines the general area of the 3468A/B that causes the failure and the second level has specific troubleshooting information for the area that fails. Unless otherwise specified, refer to Schematic 1 when using the troubleshooting procedures.



*The instrument contains CMOS Integrated Circuits (e.g. U102) which are extremely susceptible to failures due to static discharge. It is especially important that grounded tools and wrist straps be used when handling or troubleshooting these components.*

### 7-A-3. PRE-TROUBLESHOOTING INFORMATION

7-A-4. Before doing any troubleshooting procedures, perform the following:

a. Check the 3468A/B's Power Supplies and make sure they are stable, have the correct value, and are not oscillating. The power supplies are as follows (see Schematic 4):

Power Supply	Checked at	Voltage Level
+ 5V	Jumper + 5	+ 4.8 V to + 5.15V
- 15V	Jumper - 15	- 14.25V to - 15.75V
+ 15V	Jumper + 15	+ 14.55V to + 15.45V

b. Check and make sure the Reference Supplies are at the correct level and quiet. The +10V supply can be checked at U405 pin 6, the -10V supply at U404 pin 6, and the buffered +10V supply at JM201 (see Schematic 3).

### 7-A-5. DC VOLTS TROUBLESHOOTING

7-A-6. Typical DC Volts Failures are Overload, Inaccurate, Constant Zero, Floating, or Noisy Readings on all or some ranges. The following paragraphs have the failures and the troubleshooting procedures (see paragraph 7-27 for a description of these failures).

#### 7-A-7. Overload, Floating, Constant Zero (with input applied), or Noisy Readings on All Ranges

7-A-8. If a failure is noted on all ranges, the failure can be caused by the Input Circuitry (Input Switching or DC/Ohms Input Amplifier) or by the A/D Converter. To determine the inoperative circuitry, do the procedure which follows this paragraph (the same procedure is also in Service Group D). If the procedure has been performed already, ignore the procedure and go to paragraph 7-D-21

for troubleshooting. If it has not been performed, do the following:

- a. Set the 3468A/B to the DC Volts Function and the 3V Range.
- b. Turn Autozero off by pressing the blue Shift button and then the INT/TRIG (AUTOZERO) button.
- c. Apply a stable +3V dc to the INPUT Terminals.
- d. With a Digital Voltmeter (like the 3456A) measure for +10V at JM101.
- e. Make sure the reading on the test voltmeter is a stable +10V. If the reading on the test voltmeter is a stable +10V, the A/D Converter is at fault. Go to Service Group D for troubleshooting.
- f. If the reading on the test voltmeter is wrong (overload, constant zero, floating, or noisy), unsolder and lift the end of jumper JM101 which is connected to the A/D Converter (toward the front of the 3468A/B).
- g. If the reading on the test voltmeter is now good, the A/D Converter is at fault. Go to Service Group D for troubleshooting.
- h. If the reading is still wrong, the Input Circuitry (Input Switching and DC/Ohms Input Amplifier) is at fault. Go to paragraph 7-A-21 for troubleshooting.
- i. Replace jumper JM101.

#### **7-A-9. Constant Zero Readings (with no input applied) on All Ranges**

7-A-10. Since the 3468A/B's 30V and 300V Ranges will normally have a constant zero reading with no input applied, the other ranges will also be at zero if relay K102 is shorted. Make sure the relay is good and is not being turned on by U102 (zero volts across the coil of K102). If the relay is turned on in the .3V and 3V Ranges, U102 may be defective.

#### **7-A-11. Overload, Constant Zero, Floating, or Noisy Readings on Some Ranges**

7-A-12. The Input Hybrid (U102) in conjunction with the Input Relays (K101 through K104) is used to select different paths to connect the input signals with the DC/Ohms Input Amplifier. The hybrid is also used to select the amplifier's different gain configurations. Because of this, a relay or U102 can make certain ranges fail.

7-A-13. **Overload.** An overload condition exists if the DC/Ohms Input Amplifier's feedback circuitry is open. Since the feedback circuitry is in U102, the hybrid is most likely defective.

7-A-14. **Constant Zero Reading.** The most likely cause is the Input Hybrid (U102).

7-A-15. **Floating Readings.** A floating reading is normally caused when an input path to the DC/Ohms Input Amplifier is open. Check for the following:

- a. If the .3V and 3V Ranges are defective, do the following:
  1. Short across the contacts of relay K101.
  2. If the ranges are now good, make sure K101 is energized (5V dc across the coil). If K101 is energized, replace the relay. If not, U102 may be defective.
  3. If, after replacing K101, the ranges still fail, U102 may be defective.
- b. If the 30V and 300V Ranges are defective, do the following:
  1. Short across the contacts of relay K102.
  2. If the ranges are now good, make sure K102 is energized (5V dc across the coil). If K102 is energized, replace the relay. If not, U102 may be defective.
  3. If, after replacing K102, the ranges still fail, U102 may be defective.

7-A-16. **Noise.** Noise can be caused by a FET switch internal to the Input Hybrid (U102) and U101. Replace U101 and then U102 if noise is noted on some ranges.

#### **7-A-17. Inaccurate Readings on All Ranges**

7-A-18. Inaccurate readings normally show up as other than positive full scale readings. This is because the 3468A/B is calibrated using zero and positive full scale (or 1/3 scale) inputs. Inaccurate readings can be caused by the Input Circuitry (Input Hybrid or DC/Ohms Input Amplifier). Try replacing U101 and then U102.

#### **7-A-19. PROTECTION CIRCUITRY TROUBLESHOOTING**

7-A-20. This circuitry consists of E101 and various diodes in U102. If all ranges fail, try replacing E101. If the ranges still fail or some ranges fail, the most likely cause is U102.

#### **7-A-21. INPUT CIRCUITRY TROUBLESHOOTING**

7-A-22. The Input Circuitry consists of the Input Switching Circuitry and the DC/Ohms Input Amplifier. Before troubleshooting the circuitry, make sure the failure is not caused by the A/D Converter. Go to paragraph 7-A-5 to determine the faulty circuitry, if it has not been done already.



**7-A-23. Overload Readings on All Ranges**

7-A-24. An overload can be caused when the output of the DC/Ohms Input Amplifier is too high. This can be caused by an excessive input to the amplifier, open feedback, or a defective amplifier. Do the following:

- a. Set the 3468A/B to the DC Volts Function and the 3V Range.
- b. Make sure Autozero is turned off (see paragraph 7-A-8 step b).
- c. Short the 3468A/B's INPUT Terminals.
- d. With a high impedance Digital Voltmeter (like the 3456A) measure for zero volts ( $\pm 1\text{mV}$ ) at U101 pin 3 (U102 pin 10).
- e. If the reading on the test voltmeter is other than zero volts (i.e., above 1 mV), the Input Hybrid is defective. Replace U102.
- f. If the reading is good, connect pin 6 and pin 2 (U102 pin 3 and 9) of U101 to each other. Using the test voltmeter, measure for zero volts ( $\pm 3\text{mV}$ ) at pin 6 of U101.
- g. If the reading is good (less than  $\pm 3\text{mV}$ ), the amplifier feedback circuitry is defective. Replace U102.
- h. If the reading is wrong (greater than 3mV), the amplifier is defective. Replace U101.

**7-A-25. Constant Zero Readings on All Ranges**

7-A-26. A constant zero reading is normally caused when the input or output of the DC/Ohms Input Amplifier is shorted to ground. Make sure pin 1 and pin 13 of U102 and pin 6 of U101 are not shorting to ground. If no shorts are noted, do the following:

- a. Set the 3468A/B to the DC Volts Function and the 3V Range.
- b. Make sure Autozero is turned off (see paragraph 7-A-8 step b).
- c. Using an external power supply with a 100K ohm resistor in series, apply +3V to pin 3 of U101. (Connect one end of the resistor to pin 3 of U101 and the other end to the power supply.)
- d. Using a high impedance Digital Voltmeter (like the 3456A), make sure the voltage at the resistor end connected to pin 3 of U101 is +3V.
- e. If the voltage is loaded down, the Input Hybrid is defective. Replace U102.
- f. If the voltage is +3V, measure (using the test voltmeter) for approximately +10V at U101 pin 6.

g. If the voltage is incorrect, the Input Amplifier is at fault. Replace U101.

h. If the voltage is good, the Input Hybrid (U102) may be defective.

**7-A-27. Floating Reading on All Ranges**

7-A-28. A floating reading is normally caused when an open exists between the DC/Ohms Input Amplifier and the instrument's INPUT Terminals. Before troubleshooting the instrument, make sure the wires from the INPUT Terminals to the mother board are good. If they are good, do the following:

- a. Set the 3468A/B to the DC Volts Function and the 3V Range.
- b. Make sure Autozero is turned off (see paragraph 7-A-8 step b).
- c. Using an external power supply, apply +3V to the 3468A/B's INPUT Terminals.
- d. Connect the 3468A/B's HI INPUT Terminal to U101 pin 3 (U102 pin 10).
- e. If the displayed reading on the 3468A/B is still a floating reading, replace U101.
- f. If the displayed reading on the 3468A/B is +3V, the Input Hybrid (U102) may be at fault.

**7-A-29. Noisy Readings on All Ranges**

7-A-30. Noisy readings can be caused by the Input Hybrid or the DC/Ohms Input Amplifier. Do the following:

- a. Set the 3468A/B to the DC Volts Function and the 3V Range.
- b. Make sure Autozero is turned off (see paragraph 7-A-8 step b).
- c. If the reading on the 3468A/B is quiet with Autozero off, the Input Hybrid is defective. Replace U102. If the reading is still noisy, continue with the next step.
- d. Connect pin 6 and pin 2 (U102 pin 3 and 9) of U101 to each other.
- e. Apply a stable +3V to the 3468A's INPUT Terminals.
- f. Using a high impedance Digital Voltmeter (like the 3456A) measure for a stable +3V at U101 pin 3.
- g. If the voltage is noisy, replace the Input Hybrid (U102).

h. If the voltage is stable, measure for a stable +3V at pin 6 of U101.

i. If the voltage is noisy, replace U101. If the voltage is stable, replace U102 (Input Hybrid).

#### **7-A-31. DC CURRENT TROUBLESHOOTING**

7-A-32. Make sure the DC Volts Function is operating correctly on all ranges, before troubleshooting for dc current failures. Go to paragraph 7-A-5 to troubleshoot for DC Volts Failures. If the DC Volts Function is good, the only components that can cause a current failure are an open current fuse (F101), a defective resistor R107, or the Input Hybrid U102. Make sure F101 and R107 are good. If the resistor and fuse are good, U102 may be defective.

# SERVICE GROUP B

## AC VOLTS AND AC CURRENT TROUBLESHOOTING

### Service Group B Contents

Title	Paragraph
Introduction.....	7-B-1
AC Volts Troubleshooting.....	7-B-3
Overload, Floating, or Noisy Readings on All Ranges.....	7-B-5
Inaccurate Readings on All Ranges.....	7-B-8
Overload, Inaccurate, Floating or Noisy Readings on Some Ranges.....	7-B-10
AC Current Troubleshooting.....	7-B-12
Overload Protection Circuitry Troubleshooting.....	7-B-14

### 7-B-1. INTRODUCTION

7-B-2. This Service Group has the AC Volts and AC Current troubleshooting information for the 3468A/B and is symptoms oriented (i.e., what fails). Before troubleshooting for AC Volts or AC Current Failures, make sure the 3468A/B's DC Volts and DC Current Functions are operating correctly (go to Service Group A, if the functions fail). These functions must be good, before the AC Volts and AC Current Functions can operate.



*The instrument contains CMOS Integrated Circuits (e.g. U102) which are extremely susceptible to failures due to static discharge. It is especially important that grounded tools and wrist straps be used when handling or troubleshooting these components.*

### 7-B-3. AC VOLTS TROUBLESHOOTING

7-B-4. An AC Volts Failure can be Overload, Inaccurate, Floating, or Noisy Readings on all or some ranges. The following paragraphs have the failures and troubleshooting procedures (go to paragraph 7-27 for a description of these failures). Unless otherwise specified, refer to Schematic 2 for the following troubleshooting procedures.

#### 7-B-5. Overload, Floating, or Noisy Readings on All Ranges

7-B-6. An overload reading can be caused if one of the amplifiers or the RMS Converter in the AC to DC Converter is saturated. A floating reading can be caused if there is an open circuit in the AC to DC Converter. Noisy readings can be caused by any of the amplifiers in the converter, or by faulty bypass capacitors.

7-B-7. Before troubleshooting the AC to DC Converter, make sure relay K104 (see Schematic 1) is good and is energized (5V dc across the coil). If the relay is not energized, U102 may be defective. If K104 is good, do the following procedure.

- a. Set the 3468A/B to the AC Volts Function and the 3V Range.
- b. Apply a stable 3V at 1KHz sine wave to the 3468A/B's INPUT Terminals.
- c. Using a stable Digital Voltmeter (like the 3456A), measure for approximately +3V dc at jumper JM302.
- d. If the reading is a stable +3V dc, do the following:
  1. Apply 1V at 1KHz to the INPUT Terminals.
  2. If the test voltmeter now reads a stable + dc at JM302, the AC to DC Converter is good. Make sure the DC Volts Function is operating correctly.
  3. If the DC Volts Function is good, replace the A/D Hybrid (U403).
- e. If the reading is other than approximately +3V or noisy, measure for approximately .12V ac at jumper JM303. Make sure the reading on the test voltmeter is stable.
- f. If the reading is good, do the following:
  1. Measure for a stable 3V ac at pin 4 of U303.
  2. If the reading is good, replace U303.
  3. If the reading is wrong, lift the end of capacitor C304 which is connected to pin 4 of U303.



Then measure for a stable 3V ac at the lifted end of the capacitor.

4. If the voltage is good, replace U303.

5. If the voltage is still wrong, make sure the voltage at pin 6 of U302 is a good stable 3V ac.

6. If the voltage is good, capacitor C304 or C306 is defective.

7. If the voltage is unstable or wrong, connect pin 6 to pin 2 of U302 (use a very short lead to connect the pins, to prevent oscillations). If the reading at pin 6 is now a stable .12V, the feedback resistors of U302 are defective. If the .12V is wrong, replace U302.

g. If the reading at JM303 is other than .12V ac or unstable, replace U301. If the AC Volts Function is still inoperative, U102 may be defective.

#### **7-B-8. Inaccurate Readings on All Ranges**

7-B-9. Since the 3468A/B's AC to DC Converter is calibrated with an input voltage at a frequency of 1KHz, inaccuracy can result from poor frequency response.

Since the high frequency is compensated by C302 or C305, make sure the capacitors are good. If the capacitors are good, try replacing U301 and if still inaccurate, try U102.

#### **7-B-10. Overload, Inaccurate, Floating, or Noisy Readings on Some Ranges**

7-B-11. Since all ranging of the AC to DC Converter is done in the Input Hybrid U102, the hybrid is the most likely cause for ac failures on some ranges.

#### **7-B-12. AC CURRENT TROUBLESHOOTING**

7-B-13. Make sure the DC Current and AC Volts Functions are operating correctly on all ranges, before troubleshooting for ac current failures. Go to paragraph 7-B-3 to troubleshoot the AC Volts Failures and Service Group A for the DC Current Failures. If the functions are good, the only component that can cause a failure is the Input Hybrid U102.

#### **7-B-14. OVERLOAD PROTECTION CIRCUITRY TROUBLESHOOTING**

7-B-15. All of the ac functions overload protection circuitry is in U102. Replace the hybrid, if defective.

# SERVICE GROUP C

## OHMS TROUBLESHOOTING

### Service Group C Contents

Title	Paragraph
Introduction.....	7-C-1
2-Wire and 4-Wire Ohms Troubleshooting.....	7-C-4
Overload Readings on All Ranges.....	7-C-6
Inaccurate Readings on All or Some Ranges.....	7-C-8
Constant Zero Reading on All Ranges.....	7-C-10
Noise on All Ranges.....	7-C-12
Floating Readings on All or Some Ranges.....	7-C-14
Overload, Noise, or Constant Zero Readings on Some Ranges.....	7-C-16
Ohms Protection Circuitry Troubleshooting...	7-C-18
Ohms Current Source Troubleshooting.....	7-C-20
4-Wire Ohms Troubleshooting.....	7-C-22

#### 7-C-1. INTRODUCTION

7-C-2. This Service Group has the Ohms troubleshooting information for the 3468A/B and is symptoms oriented (i.e., what fails). Unless otherwise specified, refer to Schematic 1 when using the troubleshooting procedures.

7-C-3. Most ohms failures will show up in both the 2-Wire and 4-Wire Ohms Function with the troubleshooting procedure given in paragraph 7-C-4. If a failure shows up in only the 4-Wire Ohms Function, go to paragraph 7-C-22 for troubleshooting.

#### CAUTION

*The instrument contains CMOS Integrated Circuits (e.g. U102) which are extremely susceptible to failures due to static discharge. It is especially important that grounded tools and wrist straps be used when handling or troubleshooting these components.*

#### 7-C-4. 2-WIRE AND 4-WIRE OHMS TROUBLESHOOTING

7-C-5. An Ohms Failure can be Overload, Inaccurate, Constant Zero, Floating, or Noisy Readings on some or all ranges. A failure should show up with an appropriate input applied to the 3468A/B. For example, an overload failure on the 3K ohm Range should show up with a 3K ohm resistor applied to the input. The following paragraphs have the ohms failures and the troubleshooting procedures (go to paragraph 7-29 for a description of the failures).

#### 7-C-6. Overload Readings on All Ranges

7-C-7. An Overload is normally caused by a high ohms current (or an open between the INPUT Terminals and the Input Circuitry). Make sure the DC Volts Function is operating correctly before troubleshooting for an ohms failure. Do the following procedure.

a. Set the 3468A/B to the 2-Wire Ohms Function and the 3K ohm Range.

b. Connect a 3K ohm Resistor to the 3468A/B's INPUT Terminals.

c. Using a high impedance Digital Voltmeter (like the 3456A), measure the voltage between pin 17 and pin 19 of U102. Connect the low input of the voltmeter to pin 17 and the high input to pin 19.

d. If the reading on the test voltmeter is +4V dc and the 3468A/B displays an overload, the Range Resistors in U102 may be too low. Replace U102.

e. If the reading is other than +4V dc, the Ohms Current Source is defective. Go to paragraph 7-C-20 for troubleshooting.

#### 7-C-8. Inaccurate Readings on All or Some Ranges

7-C-9. This failure is normally caused when the ohms current changes value due to a load change. Do the following procedure.

a. Set the 3468A/B to the 2-Wire Ohms Function and the 3K ohm Range.

b. Connect a 3K ohm Resistor to the 3468A/B's INPUT Terminals.

c. Using a high impedance Digital Voltmeter (like the 3456A), measure the voltage across R204. Since the ohms current on the 3K ohm Range is 1mA, the voltage should be approximately .47V dc.

d. If the voltage is radically wrong, the ohms current is incorrect. Use the overload troubleshooting procedure (in paragraph 7-C-6) to determine the faulty circuitry.

e. If the voltage is good, remove the 3K ohm Resistor from the INPUT Terminals. Then short the INPUT Terminals.

f. If the voltage across R204 changes, the Output PMOS FET in U102 or the Ohms Protection Circuitry may be defective. Make sure Q201 through Q205 are good. If they are, replace U102.

#### 7-C-10. Constant Zero Reading on All Ranges

7-C-11. A Constant Zero Reading is normally caused when the ohms Current Source supplies no ohms current (current at zero value). Since no current goes through the resistor to be measured, no voltage drop across the resistor is developed and the 3468A/B measures zero volts (zero reading). A no-current condition can be caused by an open circuit between the Ohms Current Source and The INPUT Terminals, or by a defective Current Source. Do the following procedure.

a. Set the 3468A/B to the 2-Wire Ohms Function and the 3K ohm Range.

b. Connect a 3K ohm Resistor to the 3468A/B's INPUT Terminals.

c. Using a clip lead, connect pin 15 of U102 to the 3468A/B's HI INPUT Terminal.

d. If the 3468A/B still shows a constant zero reading, the Ohms Current Source is inoperative. Go to paragraph 7-C-20 for troubleshooting.

e. If the Ohms Function is now operating correctly, do the following:

1. Disconnect the clip from the HI INPUT Terminal and connect it to the collector of Q204 (junction of Q204, R203, and L201). Leave the other end of the clip lead connected to pin 15 of U102 for the checks that follow.

2. If the Ohms Function is now inoperative, check for an open Q201 through Q204.

3. If the Ohms Function is still operating, disconnect the clip lead from Q204 and connect it to the cathode of CR201.

4. If the function is now inoperative, check for an open CR201.

5. If the function is still operating, check for an open K103, R204, or L201. Make sure K103 is energized (+ 5V across the relay coil), before replacing the relay. If the relay is not energized, U102 may be defective.

#### 7-C-12. Noise on All Ranges

7-C-13. Noise on all ranges is normally caused by a noisy ohms current. Do the following procedure.

- a. Set the 3468A/B to the 2-Wire Ohms Function and the 3K ohm Range.

- b. Connect a 3K ohm Resistor to the 3468A/B's INPUT Terminals.

- c. Using a clip lead, connect pin 15 of U102 to the 3468A/B's HI INPUT Terminal.

- d. If the Ohms Function is quiet, noise is caused by the Ohms Protection Circuitry. Check Q201 through Q204.

- e. If the Ohms Function is still noisy, check the following:

1. Using a high impedance Digital Voltmeter (like the 3456A), make sure the voltage at U201 pin 6 is a quiet + 12V (< 10uV change). Replace U201, if noisy. If the voltage is still noisy, try U102.

2. If the voltage at U201 pin 6 is good, measure for a quiet + 12V at U202 pin 6 (< 10uV change). Replace U202, if noisy. If the voltage is still noisy, replace U102.

3. If the voltage at U202 pin 6 is good, replace U203. If the ohms function is still noisy, replace U102.

#### 7-C-14. Floating Reading on All or Some Ranges

7-C-15. A Floating Reading is normally caused by an open circuit between the INPUT Terminals and the DC/Ohms Input Amplifier. Make sure the DC Volts Function is operating correctly, before suspecting an ohms failure. If the failure shows up in the Ohms Function only, U102 may be defective.

#### 7-C-16. Overload, Noise, or Constant Zero Readings on Some Ranges

7-C-17. Failures on some ranges can only be caused by the Input Hybrid U102. This is because the hybrid is used to configure the current source for the different ranges. If at least one range is good, the Ohms Current Source is operating.

#### 7-C-18. OHMS PROTECTION CIRCUITRY TROUBLESHOOTING



7-C-19. The Ohms Protection Circuitry is used to protect the Ohms Current Source from excessive positive or negative input voltages. To make sure the circuitry is operational, check the following:

a. To check the circuitry operation for positive input voltages, do the following:

1. Set the 3468A/B to the 2-Wire Ohms Function and the 3K ohm Range.

2. Connect a 1K ohm resistor from pin 15 of U102 to ground.

3. Connect a high impedance Digital Voltmeter (like the 3456A) across the 1K ohm resistor.

4. Acquire a variable 0-10V power supply. Set the supply for a 0V output and connect it to the 3468A/B's INPUT Terminals.

5. Measure for approximately 1V dc across the 1K ohm resistor. If the voltage is wrong, the Current Source may be defective (go to paragraph 7-C-20 for troubleshooting).

6. Adjust the power supply until it outputs +10V. If the voltage across the 1K ohm resistor remains at approximately +1V, the Ohms Protection Circuitry does protect from positive input voltages.

7. If the voltage does not remain at +1V, replace CR201.

b. To check the circuitry operation for negative input voltages, do the following:

1. Leave the same set up as in step a, except bring the variable power supply down to 0V. The voltage across the 1K ohm resistor should again be +1V.

2. Reverse the power supply output leads and apply -10V dc to the 3468A/B's INPUT Terminals.

3. The voltage across the 1K ohm resistor should go down to approximately zero volts or some positive voltage.

4. If the voltage is good, the Ohms Protection Circuitry is operating correctly.

5. If the voltage changes polarity (negative voltage), the Ohms Protection Circuitry is inoperative. Measure for approximately -.6V at the source and drain of Q205. If the voltage is high or zero, replace Q205. If the voltage is good, check for a defective Q201 through Q204.

## 7-C-20. OHMS CURRENT SOURCE TROUBLESHOOTING

7-C-21. The Ohms Current Source consists of a Voltage Reference, Buffer and Range Resistors, and a Gate Bias Amplifier. Before troubleshooting the current source, make sure the +10V reference is good at JM201. To troubleshoot the Ohms Current Source, do the following procedure.

a. Set the 3468A/B to the 2-Wire Ohms Function and the 3K ohm Range.

b. Using a high impedance Digital Voltmeter (like the 3456A), measure the voltage at pin 2 and pin 3 of U203 (U102 pins 17 and 18, respectively). Make sure the voltage on both pins is approximately +8V.

c. If the voltages are not approximately the same, replace U203.

d. If the voltages on both pins are wrong (other than +8V), but are approximately the same, do the following:

1. Measure for approximately +12V at pin 6 of U201.

2. If the voltage at pin 6 of U201 is +12V, replace U102.

3. If the voltage at pin 6 of U201 is other than +12V, measure for approximately +8V at pin 3 of U201.

4. If the voltage at pin 3 of U201 is wrong, replace U102.

5. If the voltage is good, connect pin 6 to pin 3 of U201 (U102 pin 6 to pin 7).

6. Measure for approximately +8V at pin 6 of U201.

7. If the voltage at pin 6 of U201 is +8V, replace U102.

8. If the voltage is other than +8V, replace U201.

e. If the voltages on both pins of U203 are approximately +8V, do the following:

1. Measure for approximately +12V at pin 6 of U202.

2. If the voltage is wrong, connect pin 6 to pin 3 of U202.

3. If the voltage is now good, replace U102.

4. If the voltage is still wrong, replace U202.

f. If the Ohms Current Source is still inoperative, replace U203 and then U102.

**7-C-22. 4-WIRE OHMS TROUBLESHOOTING**

7-C-23. The only difference between the two ohms functions is that the 4-Wire Ohms Function uses the Ohms SENSE Terminals and a different input path in U102. Make sure the wires from the terminals are connected cor-

rectly. Also, make sure the lead resistance of the test used in the 4-Wire Ohms Function is not excessive ( $< 1/30$  of full scale reading in the LO INPUT lead and  $< 1/3$  of full scale in the HI INPUT lead). If everything appears to be good, U102 may be defective.

# SERVICE GROUP D

## A/D CONVERTER AND LOGIC TROUBLESHOOTING

### Service Group D Contents

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Check the Reference Voltages.....	7-D-35
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### 7-D-1. INTRODUCTION

7-D-2. This Service Group has Logic Circuitry and A/D Converter troubleshooting information for the 3468A/B. Choose the correct troubleshooting information by referring to the 3468A/B's failures and failure symptoms, given in this service group.

7-D-3. Most of the procedures in this Service Group require a Signature Analyzer (HP 5004A) for troubleshooting. In addition, two 5" Pomona clips will be useful (HP part-number 8120-1926).

### 7-D-4. THEORY OF OPERATION (CROSS REFERENCE)

7-D-5. Logic - Paragraph 7-F-50.

7-D-6. A/D Converter - Paragraph 7-F-31.

7-D-7. HP-IL - Paragraph 7-F-62.

### 7-D-8. PRE-TROUBLESHOOTING CHECKS

7-D-9. Before troubleshooting the 3468A/B for a Logic or A/D failure, check the following:

a. Check the 5V supply and make sure it is good. The supply should be between +4.9V and +5.1V. If the supply is inoperative, go to Service Group E for troubleshooting.

b. Make sure the RESET line of the Main Controller (U501pin 4) is high. If the line is low, try replacing U550 and then U504.

c. Make sure ALE at JM505 is good as shown in Figure 7-D-1. If the signal is missing or incorrect, make sure the microprocessor's clock, U501(pins 2 and 3) is 6MHz. If the clock signal is missing or wrong, try replacing the crystal Y501. If the signal is still wrong, replace U501.

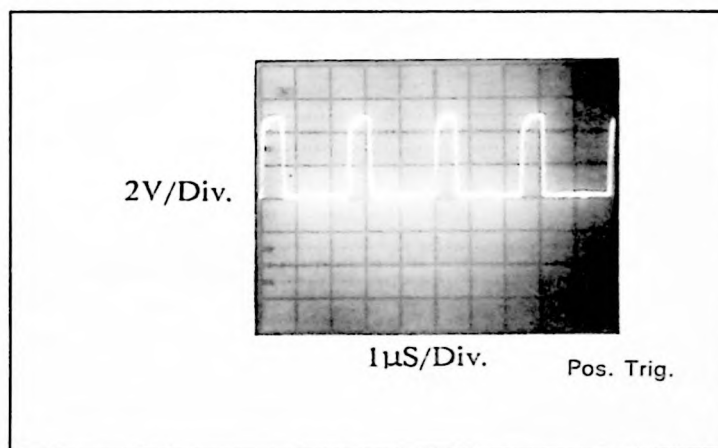


Figure 7-D-1. ALE at JM505

### 7-D-10. REAR PANEL SWITCH

7-D-11. Before troubleshooting, be sure that S501, the 8 pin dip switch located near the rear panel, has a normal operating configuration. See Table 7-D-1.

7-D-12. On the rear panel of the 3468A/B there is easy access to four of the eight pins of S501. Access to the other four pins may be gained by taking the top cover off the instrument, and gently lifting the black HP-IL input jack.



Table 7-D-1. S501 Configurations

Switch Number	Switch State	
	Open or up (0)	Closed or down (1)
1	Talk Only Mode	Normal
2	Not Used	Not Used
3	Power On SRQ	Normal
4	Not Used	Not Used
5	50Hz	60Hz
6	3468A	3468B
7	Not Used	Not Used
8	Normal	Enable Calibration

### 7-D-13. LOGIC FAILURES AND TROUBLESHOOTING



*The 3468A/B contains CMOS devices which are extremely sensitive to static electricity damage. It is especially important that grounded tools and wrist straps be used when handling or repairing the 3468A/B. All standard service procedures for preventing static electricity component damage should be followed when handling or troubleshooting these components.*

### 7-D-14. Self-Test

7-D-15. Turn off the instrument, then turn it on again. When the 3468A/B is powered on, it executes a self-test. First, it displays all segments of its display except the upper dot of the colons. It then checks its ROM, RAM, calibration RAM, and A/D converter. If the 3468A/B passes these tests, the display will read "SELF-TEST OK" for one second.

7-D-16. If Self-Test is good and you still suspect a digital failure, go to paragraph 7-D-26, General Signature Analysis (SA1).

7-D-17. If there is no meaningful information or the display is blank, go to paragraph 7-D-21, Turn-on Failure.

7-D-18. If one or more failures are detected, "ERROR dd" will appear in the display for about one second. The decimal number, dd, is the arithmetic summation of the individual error message numbers. The error message numbers are:

- 1 Calibration RAM error
- 2 RAM error
- 4 ROM error
- 8 A/D converter error

If for example, the unit had a defective ROM and was not calibrated, the display would read ERROR 5, which is error 1 (calibration RAM error) + error 4 (ROM error). Notice that any combination of errors will give a unique number.

7-D-19. The one second message can be extended by holding down any key. The message will be held in the display as long as the key is held down. After self-test the 3468A/B enters its reset state which is DC Volts, Autorange, Autozero on, Internal Trigger, and 5 1/2 Digit Display mode.

7-D-20. The following steps give a description of what each test does and what to do if it fails. When there is more than one error, solve a calibration error LAST.

a. **Calibration RAM Error (1).** This test performs a checksum on the Calibration RAM, so if the test passes, all calibration constants are stored in RAM and the RAM is probably good. It does not however guarantee that the calibration constants will make the 3468A/B meet its accuracy specifications. If the test fails, try to do a complete calibration, (see Section IV).

1. If during calibration the error message "CAL RAM BAD" is displayed, replace the Calibration RAM (U509).

2. If calibration cannot be enabled (i.e., no "C" appears in the eight character location of the display), first be sure the Calibration Enable switch is in the CAL ENABLE position (switch is down). If the switch is down, make sure the switch is good, then check for a defective U550, U509, and associated circuitry.

3. If the 3468A/B can be calibrated, set the CAL ENABLE switch up. Then turn the instrument off and on. If the Self-Test still fails, turn the 3468A/B off and measure battery BT551 and the cathode of CR551. The battery should read approximately 3V dc and the cathode of CR551 should be approximately +2.7V. If BT550 is good but CR551 is not, check C550, CR550, U509, and U550. If the battery voltage is low, something may be loading down the battery. Disconnect the plus side of the battery. If the battery voltage is still low, replace the battery. If it is good, check C550, U550, and CR550. If they are all good, replace U509.

b. **Microprocessor RAM Error (2).** This test performs a checksum on the internal RAM of the microprocessor (U501). If this test passes, the microprocessor is probably good. If this test fails, replace U501. If still inoperative, go to paragraph 7-D-24, SA0, for troubleshooting.

c. **ROM Error (4).** This test performs a checksum on the ROM (U502) so if the test passes, the ROM is probably good. If the test fails, replace the ROM, U502. If this doesn't work go to paragraph 7-D-24, SA0, for troubleshooting.

d. **A/D Converter Error (8).** This test performs a test on the slopes used in Run-up and Run-down. This test (along with another test that occurs every time an A/D conversion is made) assures you that the A/D is working properly. If this test fails, go to paragraph 7-D-33, A/D troubleshooting.

#### 7-D-21. Turn-On Failures

7-D-22. A turn-on failure is when, after power-on, the 3468A/B has a blank display, partial display, or does not give any self-test information.

7-D-23. First be sure the power supplies and clock are good. Since the display is the most likely cause of a turn-on failure, check the signatures of the lines going into the display. Do the following:

- a. Turn the 3468A/B off.
- b. Very carefully disconnect the display cable at the display.



*The display assembly, U540 is a CMOS device which is extremely susceptible to static electricity damage. Please use a grounded wrist strap when disconnecting the display cable, W501*

c. Except for switches 5, 6 and 8 (leave in present position), set all switches on S501 down (closed). Using a 5" Pomona clip lead, connect the cathode of CR520 (SA1) to ground.

d. Connect the control leads of the Signature Analyzer as indicated:

Clock - JM505 - Rising Edge  
Start - JM503 - Falling Edge  
Stop - JM503 - Rising Edge

e. Turn the 3468A/B on.

f. Check that the +5V signature is AA2F and the ground signature is 0000 before proceeding. If not, recheck connections. If the signatures are still wrong go to paragraph 7-D-24, SA0, for troubleshooting.

g. Read the signatures on the pins of the display cable, W501 (W501 may be shown as P501 on the silkscreen of the A1 board).

Pin	Signature
W501(4)	0000
W501(8)	AA2F
W501(9)	U928
W501(10)	C10C
W501(11)	5H5U
W501(12)	3PA6
W501(14)	AH0C
W501(15)	874A

h. If any signatures are wrong or unstable go to paragraph 7-D-24, SA0, for troubleshooting.

i. If the signatures are good, check the following voltages on W501 with a Digital Voltmeter.

Pin	Voltage
W501(1)	3.3V
W501(2)	2.2V
W501(3)	1.1V

j. If the voltages are good, carefully reconnect the display cable and check for 6.6KHz on C501. If good, replace the display. If the display still fails, check the continuity of the display cable.



*Use grounded tools and wrist straps when handling the CMOS display. It is extremely susceptible to static electricity damage.*

k. If the voltages on the display are wrong, does W501(pin 3) have 1/3 the voltage of W501(pin 1)? If so, R561 is probably good. The failure is caused by either the power supply or U550. If the voltage of W501(pin 3) is not 1/3 of W501(pin 1), check R561 and U550.

#### 7-D-24. Free Running SA (Processor Kernal Test) - SA0

7-D-25. To establish that basic processor operation is correct, the processor must be isolated from the data bus and the rest of the digital devices, and then examined by itself. Free Running SA (SA0) accomplishes this. For this test you will need a Signature Analyzer and two 5" Pomona clips or their equivalent. Do the following:

a. Turn the 3468A/B off.

b. Put the switches of S501 in a configuration for normal operation. Refer to table 7-D-1.

c. Use one 5" Pomona clip to connect +5V to R567 (the side of R567 connected to U502, pin 20). Most instruments will have "SA0" silkscreened on the proper side of R567.

d. Use another 5" Pomona clip to connect +5V to R502 (the side of R502 connected to U504, pin 2). Most instruments will have "SA0" silkscreened on the proper side of R502.

e. Using the Signature Analyzer, connect the control leads as indicated:

Clock JM505 - Falling Edge  
Start U501(23) - Rising Edge  
Stop U501(23) - Falling Edge



f. Turn the 3468A/B on.

g. Check that the +5V signature is 8P54 and the ground signature is 0000. If the signatures are wrong recheck your connections first, then check the clock and power supply (see paragraph 7-D-8). If clock and supply are good, replace U501.

h. If the signatures are good, check the signatures on the pins of U501 and U508, as shown in Table 7-D-2.

**Table 7-D-2. Free Running SA - SA0**

0000	1	40	8P54
8P54	2	39	0000
0000	3	38	8P54
8P54	4	37	8P54
8P54	5	36	8P54
8P54	6	35	8P54
8P54	7	34	8P54
8P54	8	33	8P54
8P54	9	32	8P54 or 0000
8P54	10	31	8P54
8P54	11	30	8P54
7A33	12	29	8P54
29PP	13	28	8P54
0863	14	27	8P54
HH53	15	26	8P54
HIOF	16	25	8P54
3A9A	17	24	0000
0108	18	23	8P54
F61C	19	22	4596
	20	21	2946

0000	1	20	8P54
7A33	2	19	F61C
7A33	3	18	F61C
29PP	4	17	0108
29PP	5	16	0108
0863	6	15	3A9A
0863	7	14	3A9A
HH53	8	13	H10F
HH53	9	12	H10F
0000	10	11	8P54

+ 5V: 8P54  
Grnd: 0000

i. If any signatures are wrong or unstable, check the +5V supply and the clocks first, then replace U501 or U508. If replacing the IC doesn't correct the failure, check for opens or shorts on the affected lines. Check also for two lines shorted together.

j. If the microprocessor (U501) signatures and the latch (U508) are good, SA0 is complete and the processor (barring intermittent operation) is good. Proceed to the next paragraph.

#### 7-D-26. General Signature Analysis - SA1

7-D-27. If the microprocessor passes SA0 test according to SA1. SA1 is a general signature analysis which checks the ROM (U502), the registers (U505 and U508), and it verifies that the proper signals are getting to the display

and keyboard. SA1 also verifies that the keyboard is operative and that the HP-IL is operating. For SA1 you will need only a signature analyzer. Disconnect the two Pomona clips used in SA0. The sequence described as follows applies to all parts of SA1.

a. Turn the 3468A/B off.

b. Except for switches 5, 6 and 8 (leave in present position), set all switches on S501 down (closed). Using a 5'' Pomona clip lead, connect the cathode of CR520 (SA1) to ground.

c. Turn the 3468A/B on.

d. All segments of the display should be lit, except the top dot of the colon. If not, check S501. If still inoperative, troubleshoot the display (paragraph 7-D-29).

**7-D-28. ROM Test.** Test the ROM, U502 as follows:

a. Connect the signature analyzer control leads as indicated.

Clock      R567\* - Rising Edge

Start      JM503 - Falling Edge

Stop      JM503 - Rising Edge

\*Connect the control leads to the side of R567 attached to U502 (pin 20). Most instruments will have "SA0" silkscreened on the proper side of R567.

b. Check the signatures that are listed in table 7-D-3.

**Table 7-D-3. ROM Signatures**

8057	1	24	F551
PFP5	2	23	1115
F071	3	22	9F32
P611	4	21	
17A5	5	20	0000
169H	6	19	9427
H170	7	18	6CCA
396F	8	17	PP0H
4001	9	16	H99U
A428	10	15	9PFC
50PP	11	14	UA79
0000	12	13	20AA

+ 5V: F551  
Grnd: 0000

c. If any of the signatures are wrong or unstable, replace the ROM (U502). If replacing the ROM doesn't correct the failure, the failure is most likely on the data bus. Check each line for a stuck 1 (F551) or 0 (0000), or two lines shorted together.

d. If the signatures are good, the ROM is probably good, continue with the next paragraph.



**7-D-29. Display, Register (U505,U507),and Keyboard Test.** This part of SA1 tests the registers (U505,U507), and it verifies that the display, DAC (R401-R406), and keyboard are getting the proper information. To do this test, the instrument must pass SA0 and the ROM test first.

a. Connect the Signature Analyzer leads as indicated.

Clock JM505 - Rising Edge

Start JM503 - Falling Edge

Stop JM503 - Rising Edge

b. Check the +5V signature (AA2F), and the ground signature (0000). If the signatures are wrong, be sure that your connections are correct and be sure that the instrument has passed SA0 and the ROM test. Then check for a stuck 1 or 0.

c. Check the signatures as shown in Table 7-D-4.

d. If any of the signatures of W501 are wrong or unstable, check the signatures of U505 (pins 11,12,13,14). If these signatures of U505 are good, replace U505. If that doesn't solve the problem, check the continuity of the cable. If the signatures of U505 are wrong, be sure

**Table 7-D-4. SA1 - General**

0000	1	40	AA2F	0000	1	16	AA2F	0000	1	16	AA2F		
AA2F	2	39	0000	0000	2	15	0000	0000	2	15	0000		
0000	3	38	AA2F	C10C	3	U505	14	9F62	FPU2	3	U507	14	9F62
AA2F	4	37	AA2F	3PA6	4		13	7H4F	310A	4		13	7H4F
AA2F	5	36	5H5U	874A	5		12	0P94	OPU5	5		12	0P94
AA2F	6	35	U928	AH0C	6		11	A463	5C21	6		11	A463
AA2F	7	34	0000	0000	7		10	0000	AA2F	7		10	0000
AA2F	8	33	AA2F	0000	8		9	0000	0000	8		9	0000
AA2F	9	32	0000 or AA2F										
AA2F	10	U501	31	0000									
0000	11		30	AA2F									
AA2F	12		29	AA2F									
AA2F	13		28	AA2F									
AA2F	14		27	AA2F									
AA2F	15		26	AA2F									
AA2F	16		25	AA2F									
AA2F	17		24	A463									
AA2F	18		23	0P94									
AA2F	19		22	7H4F									
0000	20		21	9F62									

5H5U	1	14	AA2F	AA2F	1	16		AA2F	1			
U928	2	13	AA2F	AA2F	2	15	874A	AA2F	2			
0000	3	R501	12	A463	3	W501	14	AH0C	AA2F	3	J502	
0000	4		11	0P94	4		13		AA2F	4		
AA2F	5		10	7H4F	5		12	3PA6	FPU2	5		
AA2F	6		9	9F62	6		11	5H5U	310A	6		
AA2F	7		8	AA2F	7		10	C10C	OPU5	7		
					AA2F	8	9	U928	5C21	8		

AA2F	1			AA2F	1				AA2F	1			
AA2F	2			874A	AA2F	2			AA2F	2			
	3	W501	14	AH0C	AA2F	3	J502		AA2F	3	J502		
	4		13		AA2F	4			AA2F	4			
	5		12	3PA6	FPU2	5			FPU2	5			
	6		11	5H5U	310A	6			310A	6			
	7		10	C10C	OPU5	7			OPU5	7			
	8		9	U928	5C21	8			5C21	8			

PU2A	1	24	AA2F	PFP5	1	22	AA2F	
PF5P	2	23	9F62	AU0F	2	21	PU2A	
AU0F	3	22	7H4F	896F	3	20	AA2F	
896F	4	U502	21	59U3	4	U509	19	AH0C
F9U3	5	ROM	20	1AF3	5	ROM	18	AA2F
1AF3	6		19	FPA4	6		17	AA2F
FPA4	7		18	P62C	7		16	AA2F
P62C	8		17	0000	8		15	AA2F
AA2F	9		16	AA2F	AA2F	9	14	AA2F
AA2F	10		15	AA2F	AA2F	10	13	AA2F
AA2F	11		14	AA2F	AA2F	11	12	AA2F
0000	12		13	AA2F				

that the instrument has passed SA0, otherwise check for stuck bus lines.

e. If the signatures of W501 are good, the information going to the display is good. Now check the signatures of J502.

f. If any of the signatures of J501 are wrong or unstable, check the signatures of U507 (pins 11,12,13,14). If the signatures of U507 are good, replace U507. If the signatures of U507 are wrong, be sure that the instrument has passed SA0, otherwise check for stuck bus lines.

g. If the signatures of J502 are good, the information going to the keyboard is good. If you still suspect a keyboard failure, go to the Keyboard Test, paragraph 7-D-30 for troubleshooting.

h. If the signatures coming from the microprocessor (U501) are good, but the ROM has some wrong signatures, replace the ROM (U502). If the Rom passes SA1 it is added confidence that the ROM is working correctly.

i. If signatures are wrong on any of the other components shown in Table 7-D-4, look for a stuck 1 or 0. The microprocessor (U501), Rom (U502), and registers (U508 and U509) are the only active components during this test.

**7-D-30. Inoperative Keyboard Test.** An inoperative keyboard is when all or part of 3468A/B operations cannot be selected from the Keyboard. This can be caused by the keyboard itself or the microprocessor. Be sure to go through SA0 and the previous SA1 test that checked the information going to the keyboard. Do the following:

a. Be sure S501 is set up as in paragraph 7-D-27 step b.

b. Connect the control leads of the signature analyzer as follows:

Clock JM505 - Rising Edge

Start JM503 - Falling Edge

Stop JM503 - Rising Edge

c. By pressing a certain front panel button, the signature on a port of U501 should change. For example, the signature on U501 pin 27 should change from "AA2F" to "310A", if the  $\equiv V$  button is pressed. From this change, it can be determined if the button (i.e., part of the keyboard) is inoperative or good. The following lists the pin numbers of U501, the button to be pressed, and the change in signature.

U501 Pin#	Press Button	Change From	Signature To
27	$\equiv V$	AA2F	310A
27	AUTO/MAN	AA2F	0PU5
27	$\equiv A$	AA2F	FPU2
27	SGL/TRIG	AA2F	5C21
28	$\sim V$	AA2F	310A
28	UP RANGE	AA2F	0PU5
28	$\sim A$	AA2F	FPU2
28	SRQ	AA2F	5C21
29	2 WIRE	AA2F	310A
29	DOWN RANGE	AA2F	0PU5
29	SHIFT	AA2F	FPU2
29	LOCAL	AA2F	5C21
30	4 WIRE	AA2F	310A
30	INT/TRIG	AA2F	0PU5

**7-D-31. HP-IL Failure.** Before troubleshooting for an inoperative HP-IL, make sure the 3468A/B is operating correctly from the front panel. Repair the front panel operation first, before troubleshooting for an HP-IL failure.

**7-D-32.** To troubleshoot the HP-IL, you will need a Signature Analyzer and an HP-IL Cable. Then do the following:

a. On switch S501, leave switches 5 and 8 in the present positions and set switch 6 to the up (open) position. The other switches are all set to the down (closed) position.

#### NOTE

*Make sure switch 6 on S501 is in the up (open) position when doing the following test. If the switch is in the down position, you will be unable to read the correct signature.*

b. Connect the control leads of the signature analyzer as follows:

Clock JM505 - Rising Edge

Start JM501 - Falling Edge

Stop JM501 - Rising Edge

c. Connect the HP-IL Cable from the 3468A/B's HP-IL Input Jack to the 3468A/B's HP-IL Output Jack.

d. Check the +5V signature (0854).

e. If the signature is good, HP-IL is operating correctly. Make sure the instrument front panel operation is good. If the signature is wrong, make sure the HP-IL Cable is making good contact. If it is, check the continuity of the HP-IL Input Connector and Output Connector (on the 3468A/B's rear panel). To check continuity, connect an ohmmeter from one outer pin to the other outer pin of the Output Connector. Do the same for the Input Connector. This checks part of the HP-IL Connectors, and T503. If there is no continuity, check for poor solder joints on the connectors, and if the joints are good, replace T503. If there is continuity, replace U503.

#### 7-D-33. TROUBLESHOOTING THE A/D CONVERTER

7-D-34. Either of two front panel error messages would indicate an A/D (Analog to Digital) converter failure. The first of the two messages is ERROR 8, which means that the failure was discovered during the 3468A/B Self-Test. The second message is A-D ERROR, which indicates the failure was discovered while the 3468A/B was attempting to take a reading. The following paragraphs will assist you in localizing faults in the A/D converter circuitry.

### 7-D-35. Check the Reference Voltages

7-D-36. As explained in the theory of operation (Service Group F), the +10V reference and the -10V reference supplies are essential for proper A/D conversion. The +10V reference should be checked at pin 6 of U402, and pins 20 and 24 of U403. The -10 volt reference should be checked at pin 6 of U405, pin 6 of U404, and pins 13, 15, 18, and 23 of U403. The reference supplies should be within  $\pm 3\%$  of 10 volts and within .02% of each other.

a. If the -10V reference is good but the +10V reference is incorrect, lift JM201. If the +10V reference is now good, the problem lies in the Ohms Converter. If the +10V is still incorrect, either U402 or U403 is defective.

b. If the -10V reference is incorrect, measure the voltage at the anode of CR401. If the voltage is not approximately -6.9 volts, either CR401 or R439 is defective.

c. If the voltage at the anode of CR401 is correct, use a clip lead to short across C431. Measure the voltage at pin 6 of U405. It should be approximately the same as the voltage on the anode of CR401. If it is not, replace U405, otherwise replace U403. Remove the clip lead.

d. If the -10V reference is correct at pin 6 of U405 but not at pin 6 of U404, replace U404.

7-D-37. If the reference voltages are correct, it will be necessary to troubleshoot the A/D converter circuitry. This is comprised of an integrator, U401; A/D converter, U403; and DAC (Digital to Analog Converter) resistors R401 to R405. Two procedures are described for troubleshooting this circuitry. The first, beginning with paragraph 7-D-38, checks only integrator U401. If it checks good, U403 is most likely defective. The second method, beginning with paragraph 7-D-40, tests the integrator; U403 DC input, comparator, and run-up/run-down; as well as the DAC resistors (R401-R405).

### 7-D-38. Integrator Test

7-D-39. The following procedures provide a simple method of troubleshooting U401, the integrator.

a. Connect one 10K ohm resistor across (in parallel with) C410.

b. Disconnect JM405. Connect a 10K ohm resistor from pin 2 of U401 to the +10V reference.

c. Measure the voltage at pin 6 of U401. It should be approximately -10V.

d. Now connect the second 10K ohm resistor to the -10V reference. The voltage at pin 6 of U401 should be +10V.

e. If either measurement (step c or d) is incorrect, replace U401.

f. Remove both 10K ohm resistors and replace JM405.

### 7-D-40. A/D Converter Circuitry Test - SA2

7-D-41. The following procedures may be used to troubleshoot the complete A/D converter circuitry. Although a storage oscilloscope, such as the -hp- Model 1741A would be beneficial, it is not necessary.



*The test in paragraph 7-D-41 cannot be made without destroying the present data in the Calibration RAM. The 3468A/B must be recalibrated, after doing the test.*

a. Remove JM 101. Connect pin 6 of U401 to pin 25 or 26 of U403.

b. Using a 5" Pomona clip lead, connect jumper JM510 (SA2) to ground. The 3468A/B display should now go blank.

c. Set up the oscilloscope as follows:

Channel A. Connect to pin 6 of U401.

Vert V/DIV.: 1V/DIV.

Channel B. Connect to pin 11 of U403.

Vert V/DIV.: .5V/DIV

Horizontal. 50mS/DIV.

Use 10:1 oscilloscope probes

d. Adjust triggering (trigger on channel A) for the display shown in Figure 7-D-2. The top display indicates the output of the integrator. The bottom display is the output of the comparator. If the top display is correct but the bottom is not, replace U403.

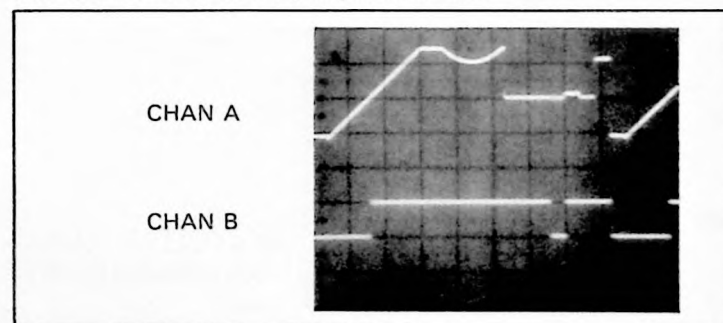


Figure 7-D-2. A/D Converter Test With Comparator



e. Adjust Channel A Vert. V/DIV to .5V/DIV. Turn off Channel B. This should provide the waveform shown in Figure 7-D-3. Any discrepancy in the left portion of the display indicates a failure in the DAC. Check resistors R401 through R405. Discrepancies in the right portion of the display indicates a failure in the run-up/run-down portion of the A/D Converter. Replace U403.

f. If the correct waveforms are noted, disconnect pin 6 of U401 from pin 25 or 26 of U403. Then replace jumper JM101 and remove the clip lead from jumper JM510 (SA2).

g. Recalibrate the 3468A/B on all ranges and functions.

7-D-42. It is possible for the microprocessor, U501, to cause an A/D failure. This would be caused by a failure of the controller to communicate with the A/D Converter U403.

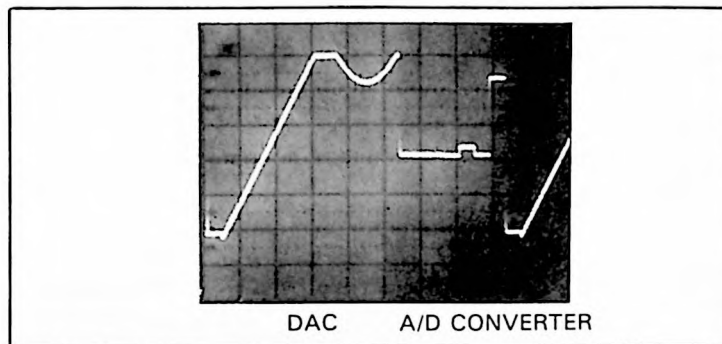


Figure 7-D-3. A/D Converter Test

# SERVICE GROUP E

## MISCELLANEOUS TROUBLESHOOTING

### Service Group E Contents

Title	Paragraph
Introduction.....	7-E-1
Power Supply Troubleshooting.....	7-E-3
Reference Circuitry Troubleshooting.....	7-E-10
Battery Charger Circuitry Troubleshooting....	7-E-12
Battery Charger Troubleshooting.....	7-E-14
DC to DC Converter Troubleshooting.....	7-E-16

#### 7-E-1. INTRODUCTION

7-E-2. This Service Group has information on how to troubleshoot the 3468A/B's Power Supplies, Reference Circuitry, and the optional Battery Charger Circuitry.

#### 7-E-3. POWER SUPPLY TROUBLESHOOTING

7-E-4. The 3468A/B has three power supplies: +5V, -15V, and +15V. The following paragraphs have some troubleshooting information for the Chassis Common and Floating Common supplies (refer to Schematic 4).

7-E-5. **+5V Supply.** A low supply can be caused by an excess load on the supply, a shorted CR712 or C705, or a defective U701. The supply can be checked by lifting jumper +5. If the supply is still low, troubleshoot the supply.

7-E-6. A high supply is most likely caused by a defective U701.

7-E-7. **+15V and -15V Supplies.** Since the -15V supply is a mirror image of the +15V supply, use the following procedure for both supplies. (The only difference is that the -15V supply has an additional filter capacitor C706.)

7-E-8. A low supply can be caused by an excessive load on the supply, a shorted filter capacitor or protection diode, an open temperature sensitive resistor (RT705), or a defective regulator. The supply can be checked by lifting jumper +15 for the +15V supply or jumper -15 for the -15V supply. If still low, troubleshoot the supply.

7-E-9. A high supply is most likely caused by the regulators (U702 or U703).

#### 7-E-10. REFERENCE CIRCUITRY TROUBLESHOOTING

7-E-11. The 3468A/B's Reference Circuitry is used to develop three reference voltages: +10V, -10V, and a buffered +10V. Since the -10V and buffered +10V depends on the +10V reference voltage, make sure the +10V is good before troubleshooting the other reference supplies. Perform the following checks (refer to Schematic 3).

a. If the +10V reference is inoperative, do the following:

1. Measure the voltage at zener diode CR401. The voltage should be quiet and at approximately +6.9V.

2. If the voltage is wrong, make sure R439 is good. If the resistor is good, replace CR401.

3. If the voltage is good, short across capacitor C431. Measure pin 6 of U405.

4. If the voltage at pin 6 is approximately +7V and quiet, replace U403.

5. If the voltage is still incorrect or noisy, replace U405.

b. If the +10V is good and the -10V is incorrect or noisy, replace U404. If still incorrect or noisy, replace U403.

c. If both +10V and -10V voltages are good and the buffered +10V is low, lift jumper JM201 (see Schematic 1). If the +10V is now good, replace U102. If still wrong, continue with the next step.

d. If the buffered +10V is wrong or noisy, do the following:

1. Check for a quiet -10V at pin 2 of U402.

2. If the voltage is wrong, replace U403.

3. If the voltage is good, connect pin 19 to pin 24 of U403.

4. If the voltage at pin 6 of U402 is now at +10V, replace U403. If not, replace U402.

#### 7-E-12. BATTERY CHARGER CIRCUITRY TROUBLESHOOTING

7-E-13. The purpose of the Battery Charger Circuitry is to allow the 3468A/B to operate on an internal battery

(BT901). The circuitry is used to charge the battery when the 3468A/B is connected to the ac power source and to generate the raw (unregulated) voltages for the 3468A/B's internal power supply. If the 3468A/B does not operate with its ac power source disconnected, check the following (refer to Schematic 5):

a. With the 3468A/B unplugged from its ac power source, turn the 3468A/B on.

b. Connect the high input of a DC Voltmeter to the positive terminal of battery BT901 and connect the low input of the voltmeter to the negative terminal of the battery. Measure for +6V dc.

c. If the voltage is at or above +6V, check for an open fuse F901 or the printed circuit board fuse (see note on Schematic 5). The printed circuit board fuse is a thin trace near J901 (J901 is a red wire going to the positive terminal of the battery). If the fuse is open, it can be replaced by a 28 gauge single strand wire. Insert and solder the wire into the holes on each end of the trace.

d. If the fuses are good and the battery is above +6V dc, troubleshoot the DC to DC Converter and associated control circuitry. Go to paragraph 7-E-16 for troubleshooting.

e. If the voltage is below 6V dc, the Battery Charger Circuitry may not be charging the battery or the battery itself is defective. Go to paragraph 7-E-14 for troubleshooting.

#### 7-E-14. Battery Charger Troubleshooting

7-E-15. The battery is charged with a current of approximately 400mA, when the 3468A/B is connected to its ac power source and turned off. Do the following to check the circuitry.

a. Turn the 3468A/B off and unplug the instrument from its ac power source.

b. Check and make sure the Battery Charger Circuitry develops the correct current for the battery. Two methods can be used to check the current. One method uses an ammeter (like the 3468A/B or 3478A) to check the current and is given in step c. The other method uses a DC Digital Voltmeter (like the 3456A) and a 10 ohm 5 watt resistor. This method is in step d.

c. To check the charge current using an ammeter, do the following:

1. Disconnect the red battery lead from the battery and connect it to the A (Amps) input of the ammeter.

2. Connect the LO input of the ammeter to the black battery lead (ground).

3. Make sure the 3468A/B is turned off, then plug the instrument into its ac power source.

4. The current should be approximately 400mA dc.

5. If the current is wrong, the battery charger is defective. Go to step e for further troubleshooting.

6. If the current is good, turn the 3468A/B on. The current should change to approximately 140mA dc. If the current does not change, replace U902. If it does change, the battery is most likely defective. Replace the battery.

d. To check the charge current using a Digital Voltmeter and a 10 ohm resistor, do the following:

1. Disconnect the red battery lead from the battery and connect it to one side of the 10 ohm resistor.

2. Connect the other side of the resistor to the black battery lead (ground).

3. Make sure the 3468A/B is turned off, then plug the instrument into its ac power source.

4. Using the Digital Voltmeter, measure the voltage across the 10 ohm resistor. It should be approximately 4V dc.

5. If the voltage is wrong, the battery charger is defective. Go to step e for further troubleshooting.

6. If the voltage is good, turn the 3468A/B on. The voltage should approximately 1.5V dc. If the voltage does not change, replace U902. If it does change, the battery is most likely defective. Replace the battery.

e. Measure for +2.5V at pin 2 of U901 (use the black battery lead as ground).

f. If the voltage at pin 2 of U901 is good, check for an open R908, R910, and R740 (see Schematic 4). If the resistors are good, check for an open CR906, and an open or shorted Q901 or Q906. If Q901, Q902, and CR906 are good, replace U902.

g. If the voltage at pin 2 is low or missing, make sure pin 1 of U901 is at least +10V. If the voltage is missing, check for an open CR901, CR902, or CR904.

h. If the voltage at pin 1 of U901 is good, replace U901. If the voltage at pin 2 of U901 is still wrong (other than +2.5V), replace U902.

#### 7-E-16. DC to DC Converter Troubleshooting

7-E-17. The DC to DC Converter develops the raw (unregulated) voltages for the 3468A/B's power supplies,



when the instrument is unplugged. The circuitry consists of two major areas, the sense circuit and the converter itself. The part of the sense circuit is used to turn the DC to DC Converter on, when the 3468A/B is unplugged from its ac power source. The other part of the sense circuit is used to turn the converter off, if the battery voltage is too low.

7-E-18. Before troubleshooting the DC to DC Converter, make sure bridge rectifiers CR906 through CR909, and CR912 through CR914 are good. Also make sure C907 through C909 are not shorted. If they are good, do the following:

- Turn the 3468A/B off and unplug the instrument from its power source.
- Unsolder and lift the end of jumper JM901 which is connected to U903 pin 4 (toward the rear of the 3468A/B).
- Turn the 3468A/B on.
- Connect the lifted end of jumper JM901 to the positive terminal of the battery.
- If the 3468A/B operates with JM901 connected to the battery, the sense circuitry is inoperative. With JM901 connected to the battery, do the following:

1. Make sure pin 2 of U903 is low. If the pin is high, check for a shorted C904. If C904 is good, replace U902. (A low is at approximately zero volts and a high is the battery voltage, approximately +6V.)

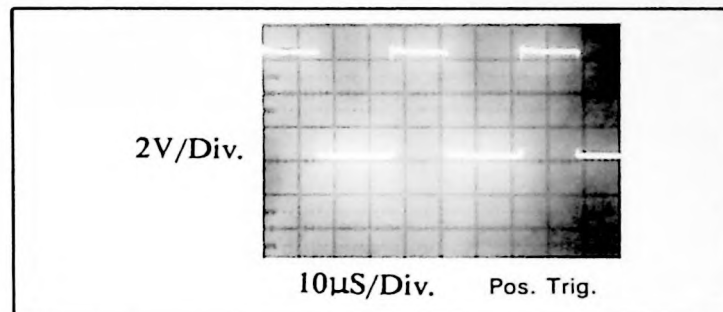
2. If pin 2 of U903 is low, check for a high level at pin 1 of U903.

3. If the level at pin 1 of U903 is high, replace U903.

4. If the level at pin 1 of U903 is low, make sure pin 4 of U902 is at approximately 2.5V. If the voltage is good, make sure pin 5 is larger than the voltage at pin 4 (above +2.5V). If it is above +2.5V, replace U902. If not, make sure R911, R912, and the battery are good.

f. If the 3468A/B is still inoperative, the DC to DC Converter itself is defective. With JM901 connected to the battery, do the following:

1. Using an oscilloscope, make sure the signal at jumper JM902 of U905 is a 28KHz square wave, as shown in Figure 7-E-1.



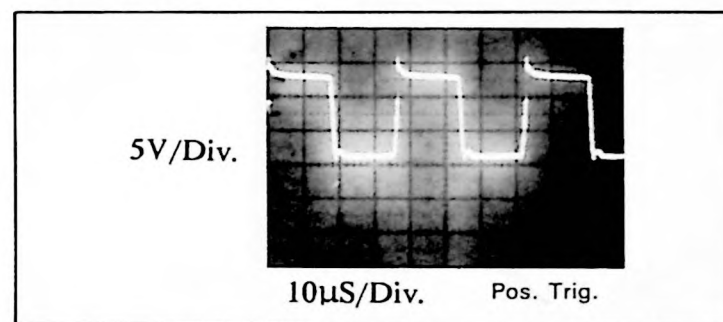
**Figure 7-E-1. Output of U905**

2. If the square wave is missing or wrong, make sure R913, R916, C911, and CR911 are good. If they are good, replace U905.

3. If the signal at JM902 is good, check for the signal shown in Figure 7-E-1 at U904 pin 11.

4. If the signal at pin 11 of U904 is missing or wrong, replace U904.

5. If the signal at pin 11 of U904 is good, check for the signal shown in Figure 7-D-2 at the collector of Q904 (pin 2 of transformer T901).



**Figure 7-E-2. Output of Q904**

6. If the signal is wrong, make sure Q903, Q904, and Q905 are good. If they are good, check for a defective transformer T901.



# SERVICE GROUP F

## THEORY OF OPERATION

### Service Group F Contents

Title	Paragraph
Introduction.....	7-F-1
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Power Supplies.....	7-F-67
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#### 7-F-1. INTRODUCTION

7-F-2. The following Service Group has the general and detailed description of the operating circuitry of the -hp- Model 3468A/B Multimeter. The general description explains the purpose of each operating block of the 3468A/B Simplified Block Diagram (shown in Figure 7-F-1). The detailed description explains the circuitry in each operating block.

#### 7-F-3. GENERAL BLOCK DIAGRAM THEORY OF OPERATION

7-F-4. Refer to Figure 7-F-1 for the following discussion of the 3468A/B's General Block Diagram Theory Of Operation.

7-F-5. The 3468A/B can be separated into two major areas, Measurement Circuitry and Control Circuitry. The Measurement Circuitry consists of the Input Circuitry, A/D Converter, Ohms Current Source, and AC to DC Converter. The Control Circuitry is used to calculate and display readings, sets up the measurement circuitry (Input Circuitry, etc.) for a particular function and range, and sends and receives remote information. It consists of the Main Controller (main CPU) and associated circuitry.

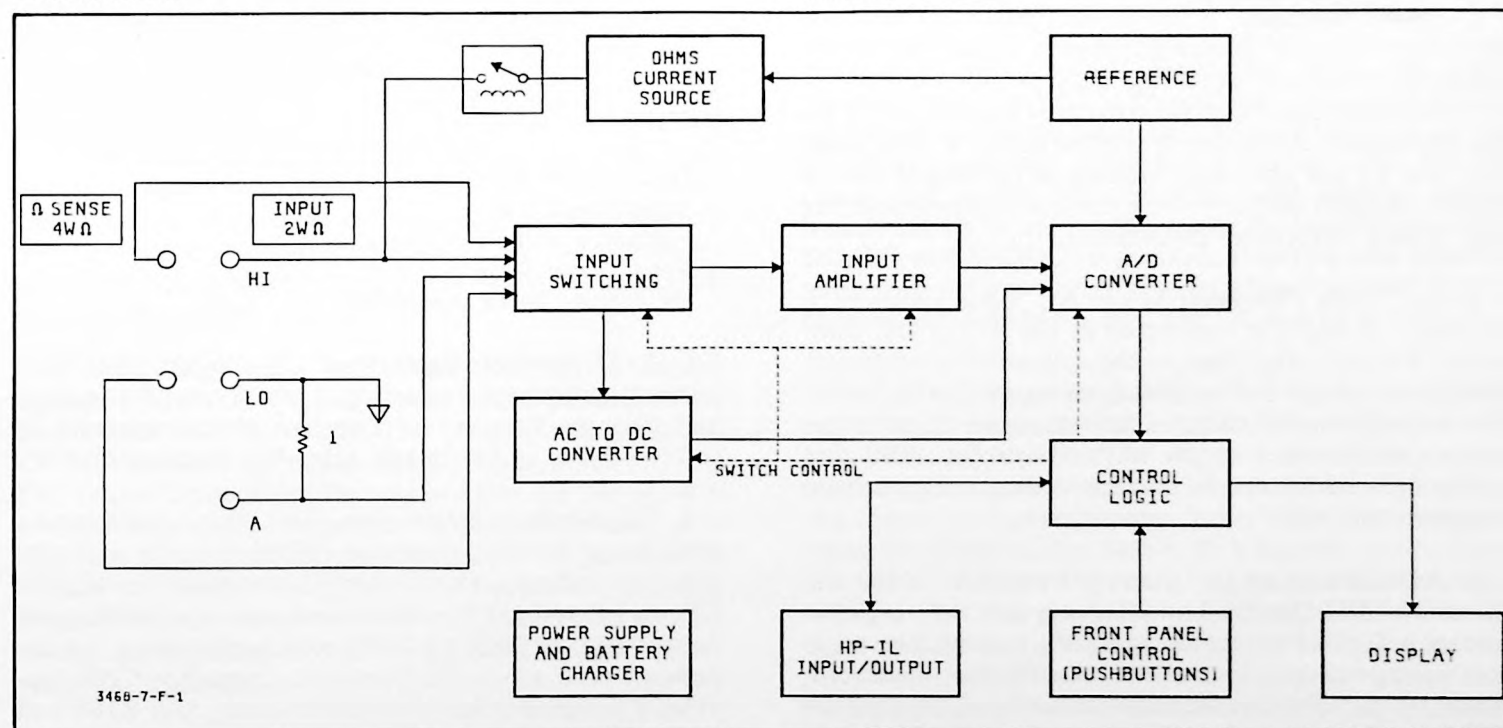


Figure 7-F-1. 3468A/B Simplified Block Diagram



7-F-6. The following paragraphs explain a typical measurement sequence.

a. **Set-up.** The 3468A/B receives range and function information from the front panel (local) or over the HP-IL (remote). The information is received by the Main Controller which then sets up the Measurement Circuitry to do the desired measurement. The Main Controller also sends information to the display to show the selected function and range.

b. **DC Volts Function.** The following occurs if the DC Volts Function is selected.

1. The Input Circuitry is set up to a certain gain configuration by the Main Controller. The gain depends on the range selected.

2. The input voltage is amplified or attenuated (dependent on the range) to 10V (for full scale inputs) which is then applied to the A/D Converter.

3. The A/D Converter changes the voltage to digital information and transfers it to the Main Controller.

4. The Main Controller takes the information and calculates the correct reading. The correct reading is calculated by using the zero measurement (see step f) and the calibration constant(s) (which are stored in the Calibration RAM).

5. The corrected reading is then sent to the front panel to be displayed and sent over the HP-IL (if the 3468A/B is in remote and addressed to talk).

c. **Ohms Function.** If the Ohms Function is selected, the Ohms Current Source supplies a dc current to the unknown resistance. A voltage drop proportional to the unknown resistance and the current is applied to the Input Terminals. A regular dc measurement is then made (see step b) and the ohms reading is calculated by the Main Controller circuitry using the zero measurement (see step f) and calibration constant(s).

d. **AC Volts Function.** If the AC Volts Function is selected, the input is connected to the AC to DC Converter. The converter changes the voltage to its equivalent (RMS) dc voltage and applies it to the A/D Converter. The A/D Converter changes the voltage to digital information and sends it to the Main Controller. The controller then calculates the correct reading using the zero measurement calibration constant(s).

e. **AC Current or DC Current Function.** If the AC Current or DC Current Functions are selected, the input current is applied to resistor A1R107 (.1 ohm). The resultant voltage drop across the resistor is then measured. An ac or dc volts measurement is made, dependent on the function selected (AC Current or DC Current, respectively).

f. **Autozero Function.** If the 3468A/B's Autozero Function is enabled, an offset measurement (known as a zero measurement) is made before an input measurement. The zero measurement is made by connecting the input of the Input Amplifier (HI INPUT Terminal is open) to ground (LO INPUT Terminal). The resultant offset of the amplifier is then measured and stored into memory. This reading is then subtracted from the DC Volts, DC Current, and Ohms readings that follow. If the AC Volts or AC Current Functions are selected, the zero reading is taken differently. The input to the A/D Converter is shorted to ground instead of the DC/Ohms Input Amplifier.

## 7-F-7. THEORY OF OPERATION

### 7-F-8. General

7-F-9. The following paragraphs give a detailed description of the operating circuitry in the 3468A/B. The circuitry is explained in the following order:

- a. Input Circuitry - paragraph 7-F-10.
- b. Ohms Current Source - paragraph 7-F-17.
- c. AC to DC Converter - paragraph 7-F-25.
- d. A/D Converter - paragraph 7-F-30.
- e. Logic Circuitry - paragraph 7-F-50.
- f. Power Supplies - paragraph 7-F-67.
- g. Battery Charger - paragraph 7-F-72.

### 7-F-10. Input Circuitry

7-F-11. **General.** The purpose of the Input Circuitry is to condition the dc input signals to the 3468A/B to provide full scale 10V dc input voltages to the A/D Converter, for full scale inputs to the 3468A/B (the explanation for ac inputs is in paragraph 7-F-25, AC to DC Converter). The Input Circuitry also acts as a buffer between the input and the A/D Converter. The circuitry can be separated (and is explained) as follows:

Overvoltage Protection  
Input Switching  
Autozero and Pre-Charge  
Pre-Charge Stage  
DC/Ohms Input Amplifier

7-F-12. **Overvoltage Protection.** This circuitry has three parts: High Voltage Protection, Low Voltage Protection, and Current Protection. The two circuits operate as follows (refer to Schematic 1 for the explanation):

a. **High Voltage Protection.** This circuit consists of a 630V Surge Voltage Protector (E101) in series with two 51K ohm resistors. The circuitry is connected between the HI and LO INPUT Terminals and conducts with a peak voltage level of 630V ( $\pm 20\%$ ), which provides a low impedance path across the terminals. Capacitor C104 provides a temporary low impedance path, and R108 and R109 provides current limiting, if E101 continuously conducts.

b. **Low Voltage Protection.** This circuit consists of diodes connected to the individual input nodes (part of the HI Input, LO Input, A Input Paths, etc.). The diodes on each node are connected (internally in U102) to +3.5V and -3.5V power supplies. If the voltage on a node exceeds either +4.2V or -4.2V, a diode conducts and keeps the level on the node to the  $\pm 4.2V$  levels. The difference between the high voltage at the input terminals and the voltage at the input nodes is dropped across the resistors which are in series with the diodes and input terminals (the low pass filter). Figure 7-F-2A shows a typical protection circuit.

c. **Current Protection.** A fuse in series with the current shunt (R107) protects the shunt from excessive input currents ( $>3A$ ) and voltage sources. Open circuit voltage of current sources should not exceed the 250V rating of the fuse.

**7-F-13. Input Switching.** The Input Switching Circuitry consists mostly of Relay and MOSFET switches, with most FET switches located in U102. The purpose of the switches is to provide five signal paths to the Input Amplifier and to connect the amplifier for a zero measurement (done in the Autozero Function; see paragraph 7-F-14). The switches are controlled by circuits in U102 which receive their control information from the A/D Controller. The following explains the various input paths. Refer to Figure 7-F-2 and Schematic 1 for the explanation.

a. **Low Voltage Range Input Path (Figure 7-F-2B).** The path consists of K101, R103, R104, R110, and S1DC (S1DC is in U102). The purpose of the path is to connect the HI INPUT Terminal (high input voltage) to the DC/Ohms Input Amplifier. The path is used only in the .3V through 3V dc volts Ranges and all Ohms Ranges.

b. **High Voltage Range Input Path (Figure 7-F-2C).** The path consists of R110, K102, S2DC (in U102), and a 100:1 divider (9.9M ohm and 100K ohm resistors, RD99 and RD98, in U102). The purpose of the path is to attenuate input voltages by a factor of 100 and to connect the attenuated voltage to the DC/Ohms Input Amplifier. The path is used only in the 30V and 300V dc volts Ranges.

c. **Ohms High Sense Path (Figure 7-F-2D).** This path consists of R105, R106, and S4ADC and S4BDC (S4ADC and S4BDC are in U102). The path connects the HI OHMS SENSE Terminal (high ohms input) to the DC/Ohms Input Amplifier, only when the 3468A/B is in the 4-Wire Ohms Function. Switch S4CDC (which is also part of the path) is used to connect the junction of S4ADC and S4BDC to ground. Switch S4CDC is closed in all functions except the 4-Wire Ohms Function and shunts any possible voltage on the S4ADC and S4BDC junction to ground.

d. **Ohms Low Sense Path (Figure 7-F-2E).** This path consists of R101, R102, S6ADC, and S6CDC (S6ADC

and S6CDC are in U102). The path is used to connect the LO OHMS SENSE Input Terminal (low ohms input) to ground (LO INPUT Terminal), when the 3468A/B is in the 4-Wire Ohms Function. In the 2-Wire Ohms Function, the low ohms input is the LO INPUT Terminal (which is connected to ground).

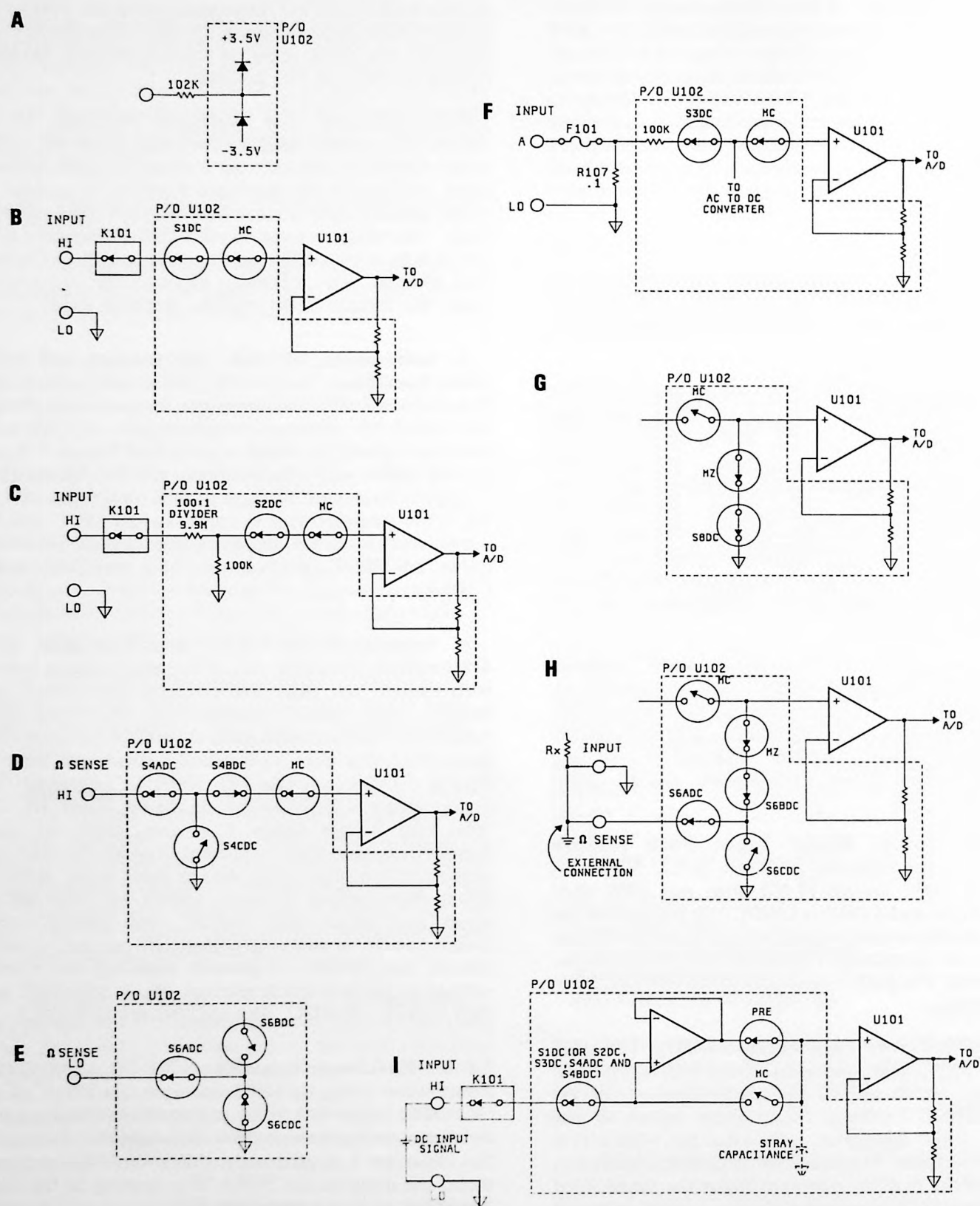
**7-F-14. Autozero.** The Autozero Function of the 3468A/B is used to measure the offset of the DC/Ohms Input Amplifier and subtract it from the input measurement. As long as the Autozero Function is enabled, an offset measurement is taken between each input measurement. The offset measurement is called "measure zero" and is done in two different ways, dependent on the function selected. The following explains the two ways to make the measurement and the circuitry used.

a. **Autozero (in DC Volts, DC Current, and 2-Wire Ohms Functions).** In the DCV, DCI, and 2-Wire Ohms Functions, the offset measurement (measure zero) is made with switch MC (measure customer) open, and switch MZ (measure zero) and S8DC closed (see Figure 7-F-2G). Switch S8DC and MZ connects the DC/Ohms Input Amplifier to ground through a 102K ohm resistor. After the offset measurement is made, switch S8DC and MZ opens, and switch MC closes for the input measurement. (Note: MOSFET switches MC, MZ, and S8DC are in U102.)

b. **Autozero (in the 4-Wire Ohms Function).** In the 4-Wire Ohms Function, the offset measurement is made with switch MC (and S8DC) open and switch MZ, S6ADC, and S6BDC closed. The DC/Ohms Input Amplifier is connected to ground through the Ohms Low Sense Path (includes an externally connected lead; see Figure 7-F-2H) to the LO INPUT Terminal. This measurement is different than in the DC Volts, DC Current, and 2-Wire Ohms Functions, since the Input Amplifier is connected to ground through the externally connected low ohms sense and lo input leads. After the offset measurement is made, switch MC and S6CDC closes and switch MZ, S6ADC, and S6BDC opens. Switch S6CDC is used to connect the junction of switch S6ADC and S6BDC to ground, shunting any possible voltage on the junction to ground. (Note: MOSFET switches S6ADC, S6BDC, and S6CDC are in U102.)

**7-F-15. Pre-Charge Stage (Figure 7-F-2I).** A small stray capacitance exists in U102 between the input of the DC/Ohms Input Amplifier and ground. During a zero measurement (measure zero in the Autozero Function), this capacitor is at zero volts. After the offset measurement, the input to the 3468A/B is applied to the Input Amplifier and the capacitor is charged to the input voltage. This charging may temporarily load down the input voltage and a wrong reading is taken. To prevent this, the input of the Input Amplifier is pre-charged to the input voltage before the input measurement is made. This is done by the Pre-Charge Amp and MOSFET Switch PRE (both in U102). The operation is as follows:





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Figure 7-F-2. Simplified Schematic Of The Input Switching Circuitry



a. After the zero measurement is made, switch PRE closes (switch MC is still open).

b. The input voltage is connected to the Pre-Charge Amp using the input paths.

c. Since the Pre-Charge Amp is a X1 gain amplifier, a voltage with the same polarity and value as the input voltage is applied through PRE to the DC/Ohms Input Amplifier. This pre-charges the stray capacitor to the input voltage.

d. Switch PRE then opens and MC closes. An input measurement is then made.

e. The same occurs before the next input measurement.

**7-F-16. DC/Ohms Input Amplifier.** The purpose of the DC/Ohms Input amplifier, in conjunction with the Input Switching Circuitry, is to condition the 3468A/B's input signals. The conditioning is done to apply the same full scale 10V dc voltage to the A/D Converter for all DC Volts, DC Current, and Ohms full scale inputs. This is done by configuring the amplifier to a gain of X3.33 or X33.3. The gains used in the 3468A/B's different ranges (in the DC Volts, DC Current, and Ohms Functions) are shown in Figure 7-F-3.

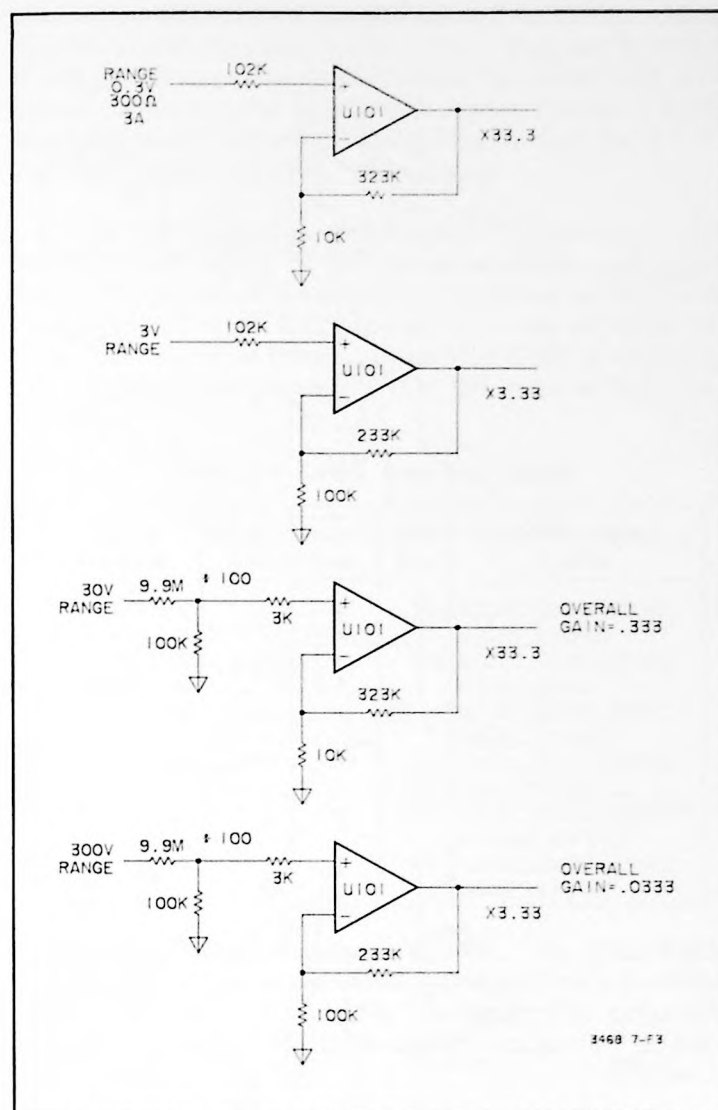
#### 7-F-17. Ohms Current Source

**7-F-18. General.** The purpose of the Ohms Current Source is to provide a stable current for resistance measurements. The current is applied to the unknown resistance and the resultant voltage drop across the resistance is measured. Since this voltage drop is directly proportional to the unknown resistance, the resistance value is determined by the 3468A/B's Main Controller from the voltage reading.

**7-F-19.** The Ohms Current Source consists of the following circuitry: Voltage Splitter (Voltage Reference), Buffer, Range Resistors, Output FET, Control Amp (Gate Bias Amplifier), Output MOSFET, and Overvoltage Protection. In addition to these, a number of MOSFETs are used as switches (to select various gain determining resistors). All the previously mentioned FETs are inside U102 which also controls the FET switches. The following paragraphs explain how the ohms current is generated and how the ohms circuitry operates. Refer to Schematic 1 and Figure 7-F-4 for the explanation.

**7-F-20. Current Generation.** The explanation on how current is generated is as follows:

a. The Voltage Splitter's (U201) output is +12V (or 8.4V for the 30M ohm Range only) which is applied to the positive terminal of Buffer U202. The reference output, which is applied to the positive terminal of the Output FET Control Amp U203, is divided down to +8V, irrespective of range, by feedback resistors RR3 and RR4 in conjunction with R201.



**Figure 7-F-3. Simplified Schematic Of The DC/Ohms Input Amplifier**

b. The output of the Buffer is +12V (or +8.4V for the 30M ohm Range only) which is applied to one side of either Range Resistor RR5, RR6, RR7, or RR8 (dependent on the selected range). The other side of the Range Resistors is applied to the Output FET Control Amp.

c. Since the Output FET Control Amp is a high gain operational amplifier with its non-inverting terminal at +8V, its inverting terminal must also be +8V (the inverting terminal draws little or no current). This makes the resultant voltage drop across the Range Resistors +4V (or +.4V for the 30M ohm Range).

d. A current is then generated with its value proportional to the value of the Range Resistor and the voltage drop across the resistor.

e. The current is applied to the unknown resistor through the Output MOSFET (in U102), High Voltage Protection Circuitry, and the HI INPUT Terminal. The 3468A/B's Ohms Ranges, Ohms Currents, Range

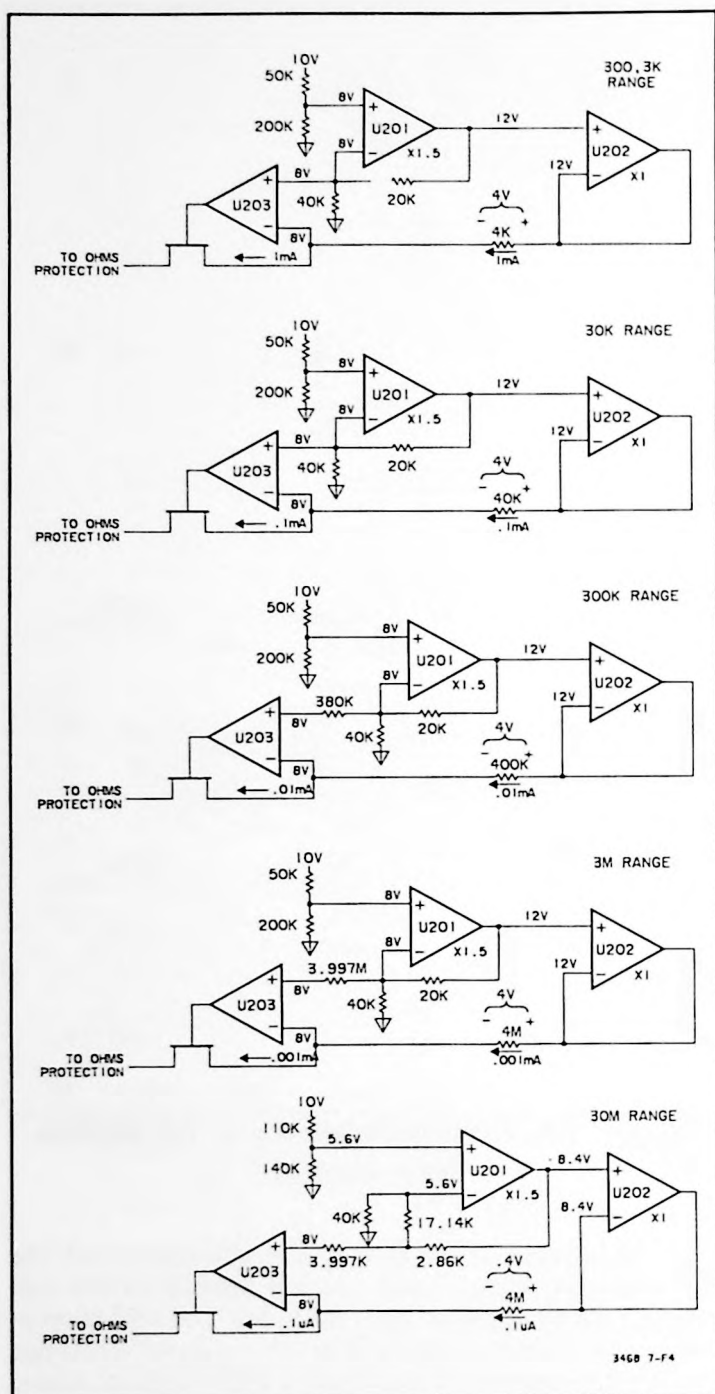


Figure 7-F-4. Ohms Circuitry Configuration

Resistors, and selected MOSFET Switches are listed in Table 7-F-1.

**7-F-21. Voltage Splitter (U201).** The following explains the Voltage Splitter (Reference) Circuitry.

a. The Voltage Splitter is a X1.5 gain non-inverting amplifier with an output of +12V (for the 300 ohm to 3M ohm Ranges) or +8.4V (for the 30M ohm Range).

b. The gain is determined by feedback resistors RR3, RR4 (both in U102), and R201. Since the total value of RR3 plus RR4 is 20K ohm and R201 is 40K ohm, the non-inverting gain is X1.5. (The gain is:  $[20K/40K] + 1 = 1.5$ ).

Table 7-F-1. Ohms Current and Ranges

Ohms Range	Ohms Current	Range Resistor	Resistor Voltage	FET Switches Enabled
300-3K	1mA	4K (RR5)	4V	S0R,S2R,S3R,S6R,S7R,S14R
30K	.1mA	40K (RR6)	4V	S0R,S2R,S3R,S8R,S9R,S14R
300K	.01mA	400K (RR7)	4V	S0R,S2R,S4R,S10R,S11R
3M	1uA	4M (RR8)	4V	S0R,S2R,S12R,S13R
30M	.1uA	4M (RR8)	.4V	S1R,S5R,S12R,S13R

c. The +12V output is generated by applying +8V to the amplifier input ( $8 \times 1.5 = 12$ ). The +8V is determined by the +10V Reference (from the 3468A/B's Reference Circuitry, see paragraph 7-F-49d) and voltage divider RR0, RR1, and RR2. The sum of RR1 and RR2 is 200K ohm and RR0 is 50K ohm resulting in a voltage drop across the resistors +8V and +2V, respectively. The +8V is applied through FET Switch S0R to U201.

d. The +8.4V output is generated by applying +5.6V to the amplifier input ( $5.6 \times 1.5 = 8.4$ ). The +5.6V is also determined by the +10V Reference (from the 3468A/B's Reference Circuitry) and voltage divider RR0, RR1, and RR2. In this case the voltage drop across RR2 (which is +5.6V developed across 140K ohm) is applied through FET Switch S1R to U201.

**7-F-22. Buffer (U202) and Range Resistors (RR5 to RR8).** The Buffer is a non-inverting X1 gain amplifier with its output at either +12V or +8.4V (on the 30M ohm Range only). The gain is selected by either MOSFET Switch pairs S6R and S7R, S8R and S9R, S10R and S11R, or S12R and S13R. The Range Resistors are used to determine the different ohms current values. Refer to Table 7-F-1 to determine which switch and resistor is selected for the different ohms ranges.

**7-F-23. The Output FET Control Amplifier (U203) and the Output MOSFET (in U102) form a feedback circuit used to boost the output impedance of the Output MOSFET. The FET is normally biased into saturation, and in conjunction with the open loop gain of U203 and the Range Resistors results in a high output impedance of the Ohms Current Source. A high output impedance is necessary to prevent measurement nonlinearities.**

**7-F-24. Overvoltage Protection Circuitry.** The circuitry is used to protect the Ohms Current Source from high voltages inadvertently applied to the 3468A/B's Input Terminals (when the multimeter is in the Ohms Function). The following explains the circuitry operation.

a. If a large positive voltage is applied to the 3468A/B's HI INPUT Terminal, the voltage is applied through R204 and L201 to the cathode of CR201. Since the cathode voltage of CR201 is higher than the anode



voltage, the diode is reverse biased. This prevents the large input voltage from damaging the current source.

b. If a large negative voltage is applied to the 3468A/B's HI INPUT Terminal, the voltage is dropped across R204, L201, and CR201, and across R203, and R202 to diode connected FET Q205. This makes Q205 conduct and in turn clamps the base of Q202 at  $-.7V$  (one diode drop). This voltage along with negative collector to base voltage forces Q201, Q202, Q203, and Q204 to turn on. Transistors Q201 and Q203 conducts no more current than the circuit which generates the ohms current (on a given range). The circuit that generates the ohms current cannot tell the difference between a valid unknown resistance and the large negative input voltage. Most of the large input voltage is dropped across R202 and R203.

c. R204 and L201 shape the initial current pulse to limit the current densities seen by the semiconductors in the current source under static discharge conditions.

#### 7-F-25. AC to DC Converter

7-F-26. The purpose of the AC to DC Converter is to convert the 3468A/B's ac inputs (volts or current) to dc volts. The converter output is  $+3.00000V$  dc for all full-scale ac inputs with the output applied to the A/D Converter. All ac ranging is done in the AC to DC Converter.

7-F-27. The AC to DC Converter consists of three amplifier stages and a True RMS Converter. The purpose of the amplifier stages is to provide the same full scale input voltage to the RMS Converter for all full scale ac inputs, and to be a buffer between the converter and the ac inputs. The True RMS Converter does the actual ac to dc conversion. The following explains the circuitry operation.

**7-F-28. Amplifier Stages.** Refer to Figure 7-F-5 and Schematic 2 for the following explanation.

a. The first amplifier stage (U301A) is an inverting amplifier with gains of X.001, X.1, or X1 (dependent on the ac range and function selected). The gains are determined by resistors RA1, RA2, RA3, and RA11 (all in U102; RA11 is shown on Schematic 1), as shown in Figure 7-F-5. Capacitor C302 and resistor R305 are used for high frequency compensation (for flat gains at high frequency). The gain determining resistors are selected by MOSFETS S1AC through S6AC, and S11AC (all in U102) which operate as switches. The gains of the amplifier and FETs selected for the ac functions are listed in Table 7-F-2.

b. The second amplifier stage (U301B) is an inverting amplifier with gains of X.4 or X4 (dependent on the ac range and function selected). The gains are determined by resistors RA5, RA6, RA7, and RA8 (all in U102), as shown in Figure 7-F-5. The gain determining resistors are

selected by FETs S7AC to S10AC (all in U102) which operate as switches (see Table 7-F-2). Resistor RA9 (in U102) makes sure the amplifier has the same high frequency response in X4 gain as in X.4 gain. Resistors R306 and R307, and C310 and C313 are used to filter the  $+15V$  and  $-15V$  power supplies, respectively.

c. The third amplifier stage (U302) is a non-inverting amplifier with a gain of X25 in all ac ranges and functions. The output of the amplifier is applied to the RMS Converter and is 3V RMS for all full scale ac inputs in all ac functions and ranges. Capacitor C305 is used for high frequency compensation (for flat gains at high frequency).

**Table 7-F-2. AC Amplifier Gains**

Function and Range	Stage 1 Gain	Stage 2 Gain	Total Gain	Switches (FETs) Enabled
ACV 300mV	.1	4	10	S2AC,S4AC,S5AC,S8AC,S10AC
ACV 3V	.1	.4	1	S2AC,S4AC,S5AC,S7AC,S9AC
ACV 30V	.001	4	.1	S1AC,S3AC,S6AC,S8AC,S10AC
ACV 300V	.001	.4	.01	S1AC,S3AC,S6AC,S7AC,S9AC
ACI 300mA	1	4	100	S4AC,S5AC,S8AC,S10AC,S11AC
ACI 3A	1	.4	10	S4AC,S5AC,S7AC,S9AC,S11AC

**7-F-29. True RMS Converter (U303).** The True RMS Converter's output is a positive dc voltage with its value equal to the true rms value of the input. For example, a sine wave input of 1V RMS ac generates a  $+1V$  dc output.

7-F-30. Refer to Schematic 2. The RMS Converter has one major stage that does the actual conversion and a buffer (used as an output stage). The converter stage and the buffer are externally connected by R304. Pin 9 of U303 is the input to the buffer and pin 10 is the output of the converter stage. The gain of the buffer is X1 which is internally set.

#### 7-F-31. A/D Converter

**7-F-32. General.** The A/D Converter is used to change dc voltages to digital information. The circuitry consists of an Integrator (U401 and associated circuitry), Voltage Reference (CR401 and associated circuitry), and the A/D Hybrid (U403). The A/D Converter operation is controlled by the Main Controller (U501).

7-F-33. The A/D conversion method used by the 3468A/B is called Multi-Slope II and has two operating states: Runup and Rundown. The 3468A/B's most significant digits are determined during runup (see paragraph 7-F-41) and the least significant digits are determined during rundown. The integration time depends on the selected Number Of Digits Displayed (3 1/2, 4 1/2, or 5 1/2). To help understand Multi-Slope



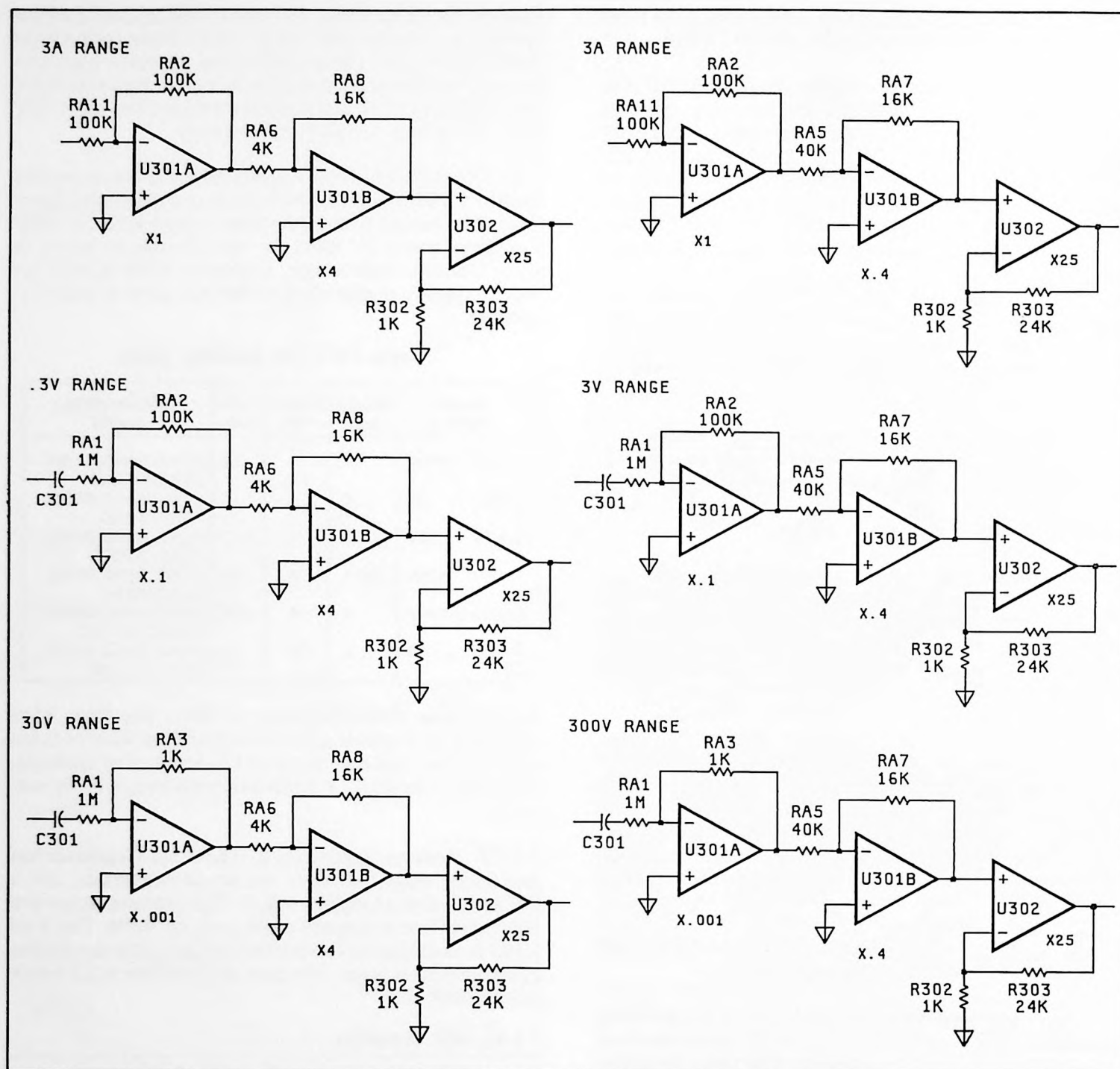


Figure 7-F-5. AC Gain Configurations

II, first consider the operation of the Dual-Slope Conversion method. This method is explained in the following paragraph.

**7-F-34. Dual-Slope Conversion.** In dual-slope conversion, an integrator capacitor charges for a fixed time period (as shown in Figure 7-F-6), which is done during runup. The charging rate and the resultant amplitude of the charge is proportional to the voltage applied to the integrator. The integrator capacitor is then discharged at a fixed rate determined by a known reference voltage and is done during rundown. Since the discharge rate is constant, the discharge time is proportional to the amplitude

of the charge (input voltage). The amplitude level can then be determined by the discharge time.

**7-F-35. Multi-Slope II Conversion.** Multi-Slope II is similar to Dual-Slope in that a capacitor is charged and discharged by the input voltage and by known reference voltages. The following paragraphs explain the Multi-Slope II operation (runup and rundown).

**7-F-36. Simplified Explanation of Runup.** The Runup operation lasts for 317 A/D counts with one A/D count equal to 20 (24 in the 50Hz option) cycles of the ALE clock (Address Latch Enable at U501 pin 11). Each A/D

count results in one A/D ramp (or slope) at the output of the A/D Integrator. The same time is used in both the 5 1/2 and 4 1/2 digit mode (317 ramps), with 10 readings taken in the 5 1/2 digit mode (making the integration time longer, see paragraph 7-F-40). Only 34 ramps are used in the 3 1/2 digit mode. The ALE clock is generated by the Main Controller (U501, also known as the Main CPU). Refer to Figure 7-F-7 and Figure 7-F-8 for the following simplified explanation of the runup operation.

a. When runup starts, the input voltage (A/D Converter input voltage, not instrument input voltage) is applied to integrator U401. The resultant input current ( $I_{in}$ ) then charges integrator capacitor C410 and a certain slope (output of the integrator) is then developed. This happens at time period T1 (see Figure 7-F-8). (The input voltage is always during runup.)

b. After time period T1, a negative going current is applied to the integrator for a set time period. This cur-

rent, in addition to the input current, charges C410. This generates a positive going output slope (the integrator output). The applied current makes sure that the output slope that follows will cross zero, whether the input current is positive or negative. The current is applied for time period T2.

c. After time period T2, the applied current (not the input current) is removed and a current of opposite polarity is then applied to U401 for new time period T3 (T3 is twice as long as T2). The newly applied current is the same value as the first applied current (at time T2), but at opposite polarity. The new current then charges C410 in the opposite direction (C410 is discharged). This is because the applied current is larger than the input current.

d. When time T3 is completed, the A/D Controller determines if the output slope crossed zero. If zero crossing is detected, a current with the same value, but at op-

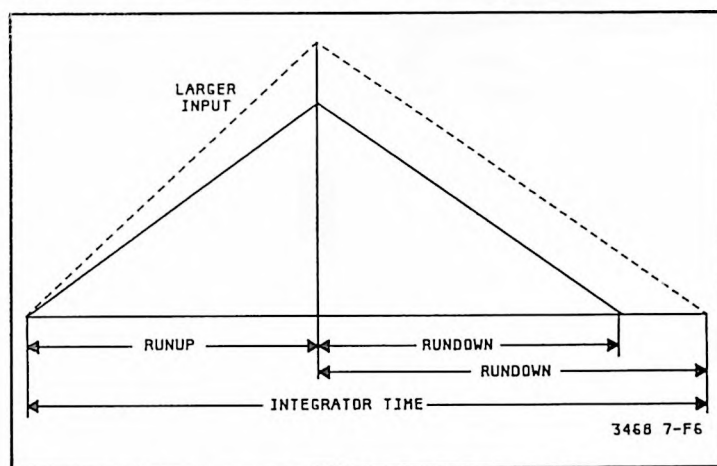


Figure 7-F-6. Dual Slope Conversion

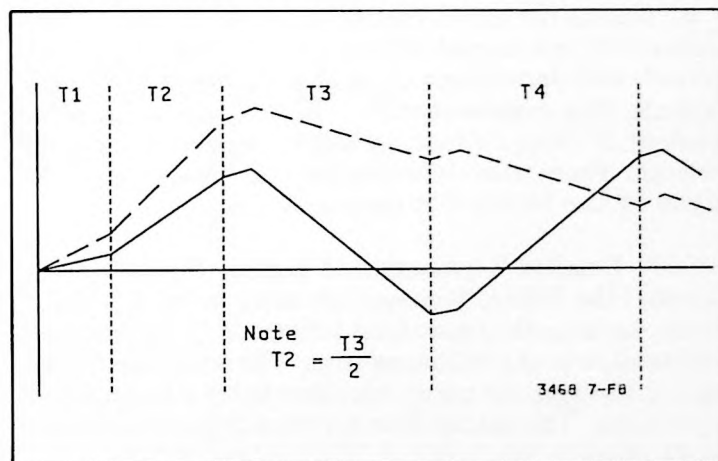


Figure 7-F-8. Integrator (U401) Output Slopes

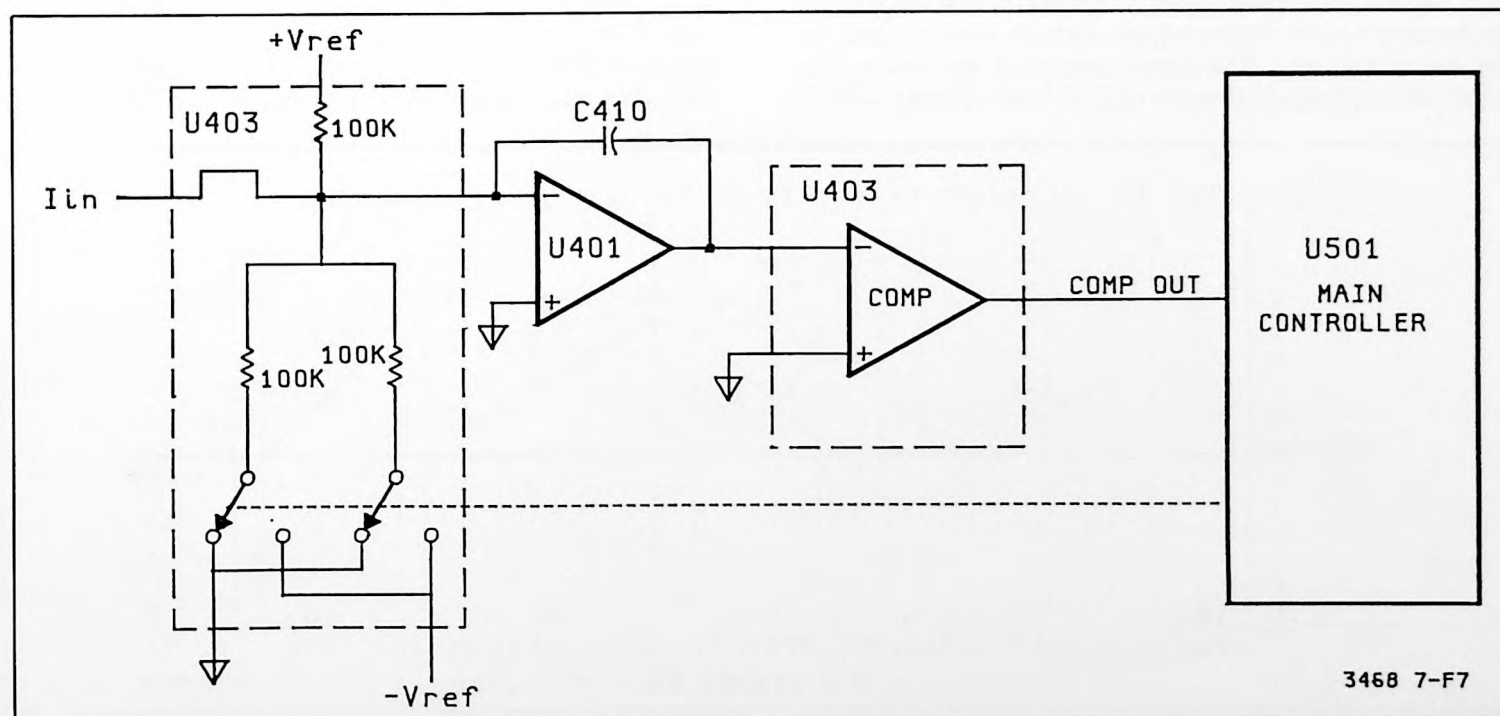


Figure 7-F-7. Simplified A/D Converter

posite polarity, as the previously applied current is applied. This current is the same current as the first applied current and is applied to the integrator for a new time period T4 (T4 is as long as T3). This current, in addition to the input current, then charges C410. Since both currents charge C410, the output slope becomes steeper and, as shown in Figure 7-F-8, crosses zero.

e. If no zero crossing (in step c) was detected (because of a larger input voltage), the same current as the previously applied current is applied for the new time period T4. The current is reapplied until zero crossing is detected. (This is shown as the dashed lines in Figure 7-F-8).

f. The operation in steps c and d, or in steps c and e continues until the runup operation is completed. The total runup operation lasts for 317 ALE ramps (or counts).

g. During the runup operation, a counter in the Main Controller increments during the positive going slope periods and decrements during the negative going slope periods. The counter, in effect, is used to determine the amount of charge added and subtracted from the input voltage. From that information, the most significant digits of the 3468A/B's reading is calculated.

**7-F-37. Detailed Explanation of Runup.** Figure 7-F-9 illustrates the 3468A/B runup operation in the 4 1/2 digit mode. Refer to the figure (and Schematic 3) for the runup explanation in the following steps. The solid lines (in the figure) showing the runup sequence is for a hypothetical input value. The dashed lines are for a larger hypothetical input value.

a. When runup starts, the integrator capacitor (C410) is charged by the input current (which is developed by the input voltage). The input current is applied to the negative terminal of integrator U401 (see Figure 7-F-7),

and since the integrator is in the inverting configuration, the resultant output of U401 is positive (for positive input currents the slope is negative). The capacitor is charged for a short time period.

b. During the time period when only the input current is applied, no other currents charge C410. Since no other current is applied to U401 (except the input current), it is called a no-current condition and the resultant output slope is called slope S + 0.

c. After the time period, a negative current (called S-4) is then applied to U401. This current develops a positive going output slope which is called slope S-4. The S-4 current is always the first current applied to the integrator after the input current is applied. The current is applied for 10 ALE cycles (12 ALE cycles in the 50 Hz option) and is for time period T1. Since the input current and the applied current in the example have the same polarity, both charge C410. If the input current was at opposite polarity, C410 will still be charged in the same direction but the output slope will be less steep. This is because the applied current (S-4) is normally larger than the input current.

d. After time period T1, current S-4 is removed. A no-current condition (slope S-0) will then exist for 1 ALE cycle (1 ALE cycle or sometimes 2 ALE cycles for the 50Hz option) during time period T2. The charge rate of Capacitor C410 is again determined by only the input current. Slope S-0 is also a no-current condition, as is slope S + 0. The major difference is that the slopes are generated differently (see paragraph 7-F-39). Slope S-0 is selected since the previous no-current condition was slope S + 0. The slopes alternate with each other (S + 0, S-0, S + 0, etc.) for each no-current condition.

e. When time T2 is completed, an S + 4 current is applied for 20 ALE cycles (24 ALE cycles for the 50Hz option) during time period T3. The S + 4 current has the

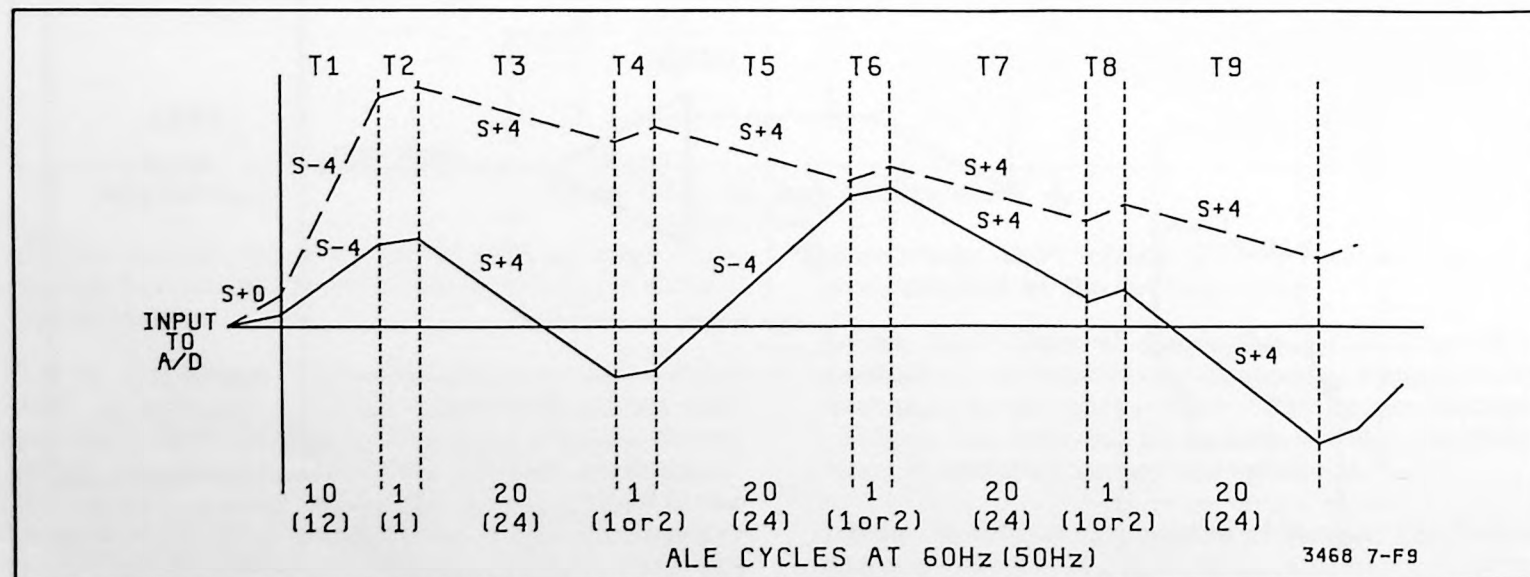


Figure 7-F-9. Runup Slopes (4 1/2 Digit Mode)



same value as S-4, but at opposite polarity. This charges C410 in the other direction (i.e. the capacitor is discharged and then charged in the other direction). Time periods T3, and the T5, T7, and T9 periods that follow, are twice as long as time period T1 (20 or 24 ALE cycles instead of 10 or 12 ALE cycles).

f. After time T3, the S + 4 current is removed and no current (slope S + 0) is applied for time T4. Time T4 is as long as time period T2 (1 or 2 ALE cycles). This is also the same time for the S-0 or S + 0 slopes that follow.

g. When T4 is completed, the Main Controller then determines if the output slope has crossed zero. Zero crossing occurs when the A/D comparator's output (CMP output at U403 pin 11) changes state. In the example, zero crossing is detected and current S-4 is applied for time T5 (20 or 24 ALE cycles).

h. After time T5, current S-4 is removed and no current (slope S-0) is applied for time T6. Since zero crossing was detected (during time T5), current S + 4 is applied for time T7, after slope S-0 is completed.

i. When time T7 is completed, no current (slope S + 0) is applied for time T8. Since no zero crossing was detected, current S + 4 is reapplied for time T9 (after slope S + 0).

j. Since zero crossing was detected during time T9, current S-4 is applied (after slope S + 0) for 20 (or 24) ALE cycles. Then S + 4 is applied (since zero crossing is detected) and so on. This takes place until the runup time is completed (either current S + 4 or S-4 is selected, dependent upon if and when zero crossing occurs).

k. Once the runup operation is completed, U501 then determines the 2 most significant digits of the reading. For other than a zero reading, the number of S + 4 slopes will always be different than the number of S-4 slopes.

For a perfect zero reading, the number of S + 4 slopes will be the same as the number of S-4 slopes. This is represented in Figure 7-F-10.

**7-F-38. Slope S + 4 and S-4 Generation.** The following explains how the currents for slopes S + 4 and S-4 are generated.

a. **Slope S + 4.** Refer to Figure 7-F-11. Note that both Y1 and Y2 paths are connected to ground. Since the summing node of the paths is a virtual ground and Y1 and Y2 are also connected to ground, no current flows between the paths and the summing node. Current does flow from + Vref (Positive Reference Voltage) through a 100K ohm resistor into the integrator capacitor (connected to the negative terminal of U401). This generates a negative going output slope.

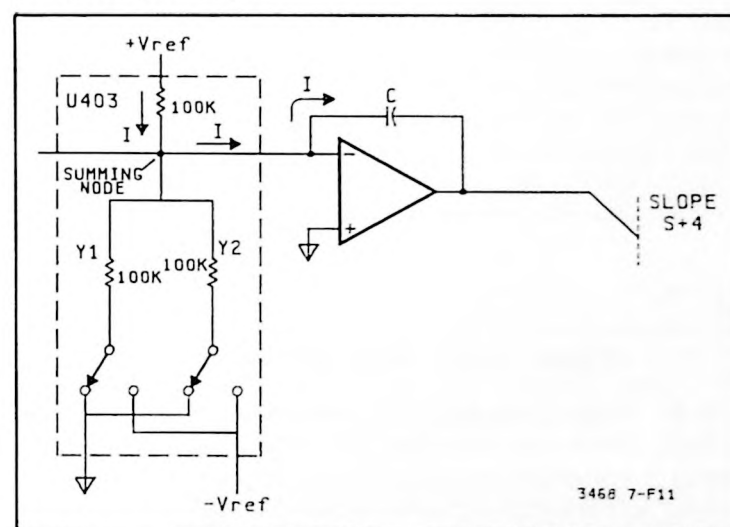


Figure 7-F-11. Slope S+4 Generation

b. **Slope S-4.** Refer to Figure 7-F-12. Note that both Y1 and Y2 paths are connected to -Vref (Negative Reference Voltage). Since the summing node is a virtual ground, current flows from + Vref through a 100K ohm

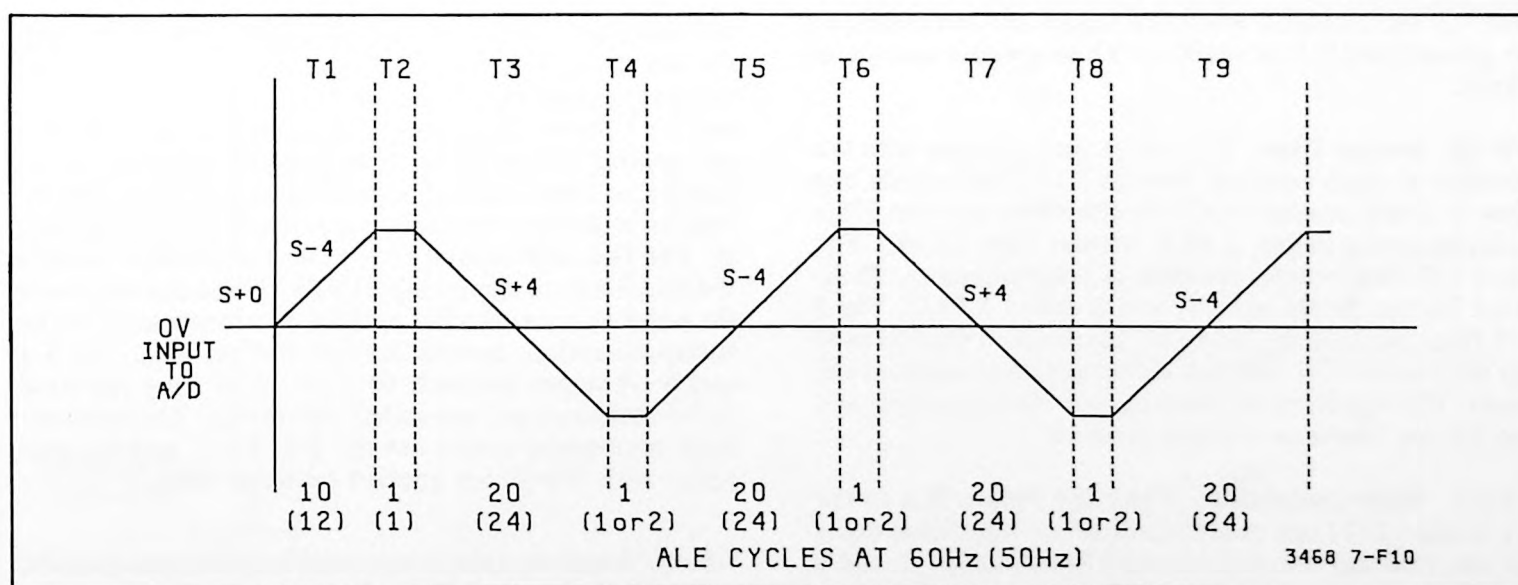


Figure 7-F-10. Runup Slopes For Zero Inputs (4 1/2 Digit Mode)

resistor and paths Y1 and Y2 to -Vref. Current also flows from the integrator capacitor (C) to -Vref. This current is generated because the total resistance of the Y1 and Y2 paths is smaller than the 100K ohm resistor from +Vref. The current from +Vref plus the current from the capacitor equals the total current through paths Y1 and Y2. Since the total resistance of paths Y1 and Y2 is 50K ohms, the current from +Vref (I1) and the current from the capacitor (I2) is half as large as the total Y1 and Y2 current (I3). The resultant output slope is positive.

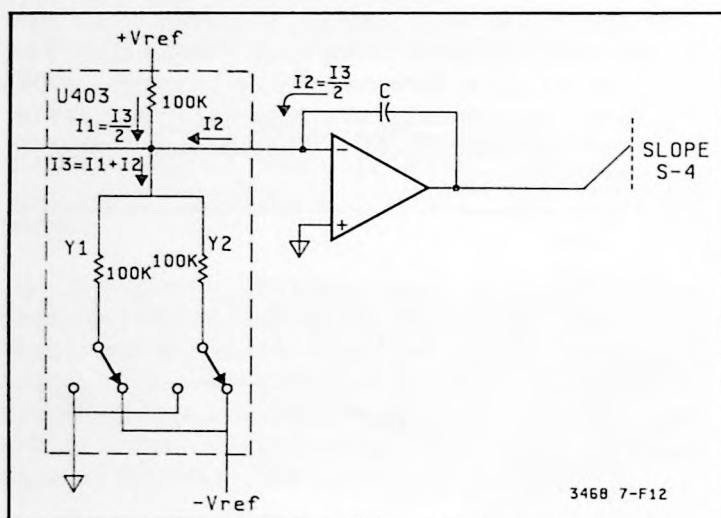


Figure 7-F-12. Slope S-4 Generation

**7-F-39. Slope S + 0 and S-0 Generation.** Refer to Figure 7-F-13. Note that one side of a 100K ohm resistor (Y1 path) is connected to ground and the other side is connected to the summing node. Since the 100K ohm resistor from +Vref (Y3 path) and the 100K ohm resistor from -Vref (Y2 path) are also connected to the summing node, no current flows from the integrator capacitor (C). This is because the resistance value of path Y2 and Y3 is the same and makes the current value of paths Y2 and Y3 the same (but opposite polarity). This is true for both slopes S + 0 and S-0. The only difference is that paths Y1 and Y2 are switched when the slopes are switched (Y1 to ground and Y2 to -Vref, or Y2 to ground and Y1 to -Vref).

**7-F-40. Runup Time.** The runup time changes with the number of digits selected. For the 3 1/2 Digit mode, the time is 1/600 second (for both the 60Hz and the 50Hz options) and is called .1 PLC (Power Line Cycles). For the 4 1/2 Digit mode, the time is 1/60 second (1/50 second for the 50 Hz option) and is called 1 PLC. The 5 1/2 Digit mode is different. In this mode, 1 PLC is used for the runup time with the A/D operation repeated ten times. The resultant ten readings are then averaged and the answer becomes a single reading.

**7-F-41. Digit Generation.** When the 3468A/B is in the 4 1/2 and 5 1/2 Digit mode, the first two significant digits (of the reading) are determined during runup. In the 3 1/2 Digit mode, only the first digit is determined. In rundown, the three least significant digits are determined

in all modes. A total of 5 1/2 digits are developed in both the 5 1/2 and 4 1/2 digit modes. Since only 4 1/2 digits are displayed in the 4 1/2 digit mode, the last digit in the mode is rounded off to the next higher digit.

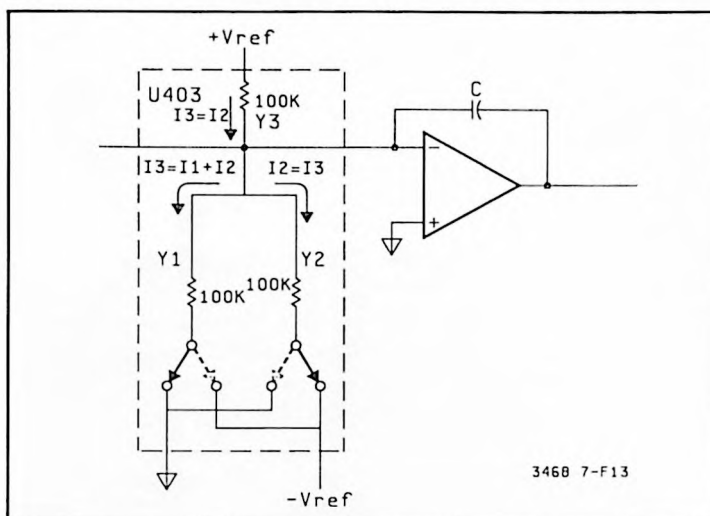


Figure 7-F-13. Slope S+0 and S-0 Generation

**7-F-42. Rundown.** When runup is completed, the voltage at the A/D Converter's input is removed and the input is then connected to ground. The rundown operation then starts. Rundown is used to determine the three least significant digits of the 3468A/B's reading.

**7-F-43.** After runup, a voltage (or charge) remains on the integrator with its amplitude and polarity dependent on the last current applied (S + 4 or S-4) and the input voltage (applied during runup). By obtaining the value of the remaining voltage, the least significant digits can then be determined. The voltage value is obtained by applying various currents to the integrator, and counting the number of times the currents have to be applied for the resultant output slopes of the integrator to cross zero.

**7-F-44.** The currents applied to the integrator are called the S-4, S + 4, S-3, S + 2, S-1, and S + 1 currents and the resultant output slopes are the S-4, S + 4, S-3, S + 2, S-1, and S + 1 slopes. Each one of the currents (S-4, S + 4, etc.) are applied (in the given order) to the integrator a set number of times until zero crossing occurs. The only exception is the first S-4 current (see paragraph 7-F-45 step c). The first and second set of currents applied are the S-4 and S + 4 currents, respectively. These currents have the same value as the S-4 and S + 4 currents used in the runup operation, but are applied half as long. The S-4 and S + 4 slopes are each 10 ALE cycles long (20 ALE cycles in runup) and are called half-ramps. The next currents applied (in order) are the S-3, S + 2, and S-1 currents, with S-0 slopes applied between them.

**7-F-45.** Rundown time is separated into five time periods, as shown in Figure 7-F-14. Refer to the figure for the following explanation on the rundown operation.



a. When rundown starts, the polarity of the remaining voltage on the integrator is determined by the Main Controller (U501). The polarity is determined by the output state of the A/D comparator (CMP output at U403 pin 11). A high output level shows a positive voltage and a low level shows a negative voltage.

b. If it has been determined that the remaining voltage on the integrator is negative, S-4 currents are applied a number of times until zero crossing occurs (CMP output changes state). Since the S-4 currents can be applied (during time T1 in Figure 7-F-14) to a maximum of three ramps, the resultant output slope S-4 will normally cross zero with three or less S-4 currents applied. After zero crossing occurs, the current is removed within 10 ALE cycles (i.e. one half-ramp) after the S-4 slope crosses zero. If (after the current is removed) time T1 is not completed, a no-current condition remains (i.e., an S-0 slope) for the rest of time T1. No current is applied to keep the run-down time constant.

c. If the remaining voltage on the integrator is positive, current S-4 is applied for a short time and then removed. The current is applied for a short time because the current develops a positive output slope and the integrator voltage is also positive. Both the slope and the integrator voltage together could saturate the integrator. When Current S-4 is removed, no current (an S-0 slope) is then applied for the rest of time T1. Current S-4 is applied whether the integrator voltage is positive or negative. This is to make sure that the slopes that follow (slope S+4) will always cross zero and that the same transitions occurs for all readings.

d. The next current applied is positive S+4 current. Its value is the same as S-4, but in the opposite direction. The current is applied until slope S+4 crosses zero. The current can be applied (during time T2) a maximum of three ramps. This makes time T2 the same as time T1.

The S+4 currents are also removed within 10 ALE cycles after the S+4 slope crosses zero. Here again, no current is applied (slope S-0) for the remainder of time T2.

e. After time T2, the next current applied is negative S-3 current (its polarity is opposite of S+4). Because the value of an S-3 current is 1/10 the value of an S-4 current, the resultant S-3 slope is not as steep and takes a longer time to cross zero. This makes the maximum number of times the currents can be applied (during time T3) seven times instead of three. The S-3 current is also removed within 10 ALE cycles after slope S-3 crosses zero. Then no current (S-0) is applied for the remainder of time T3.

f. When time T3 is completed, positive current S+2 is applied. This current is 1/10 the value of S-3 (1/100 of S-4) and in the opposite direction. The maximum number of times the S+2 current can be applied is seven (as are S-3 currents). Time T4 has the same amount of time as T3. The S+2 currents are also removed within 10 ALE cycles after slope S+2 crosses zero. Then no current (S-0) is applied for the remainder of time T4.

g. The next current applied is negative S-1. This current is 1/10 the value of S+2 (1/1000 of S+4) and in the opposite direction. The current is applied until it crosses zero. The currents are also removed within 10 ALE cycles after slope S-1 crosses zero.

h. Once the S-1 currents are removed a positive S+1 current is applied for 5 ALE cycles and is called one quarter ramp. This current is applied instead of no current and only happens after the S-1 slope. The current has the same value as S-1, but in the opposite direction. The currents are applied until zero crossing occurs and are removed within 5 ALE cycles after crossing zero.

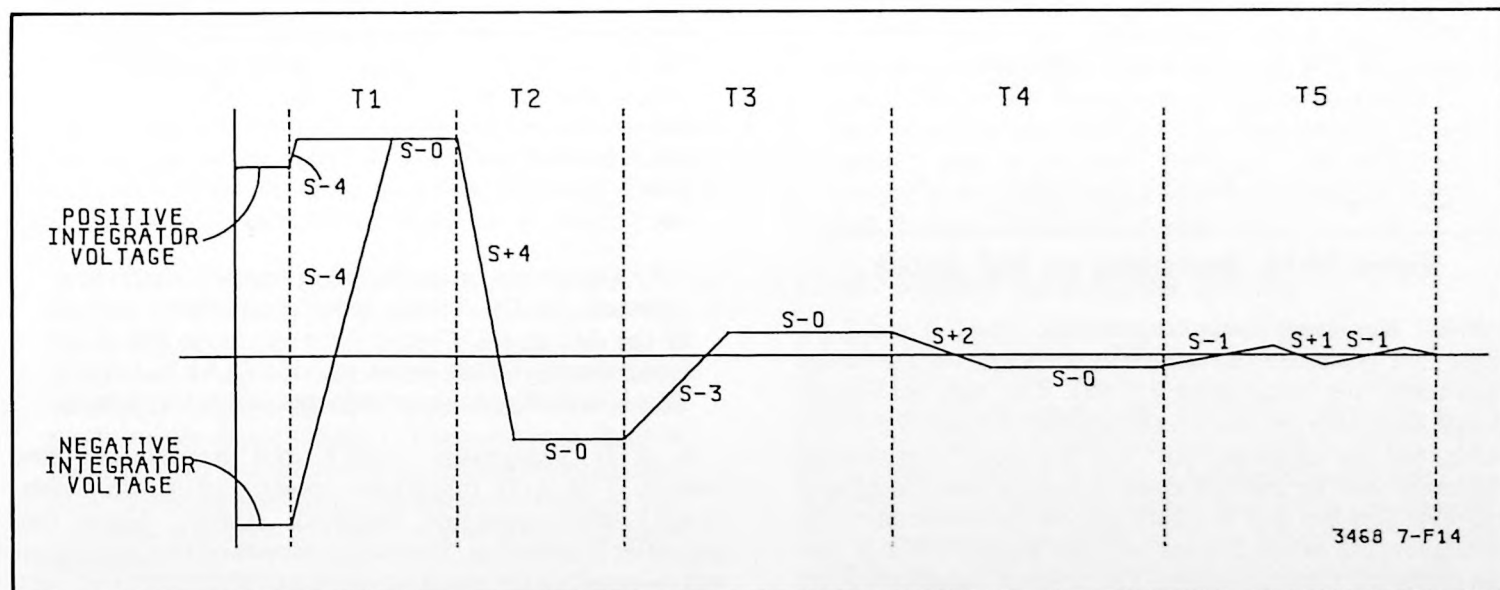


Figure 7-F-14. Rundown Slopes

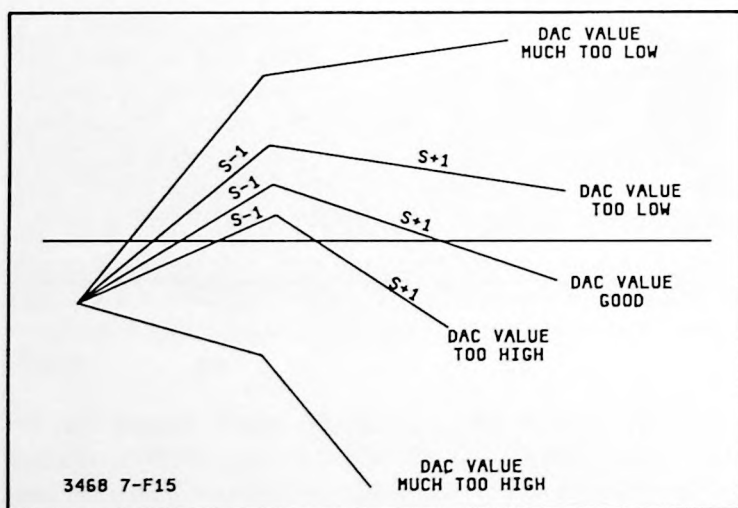


i. After current  $S+1$  is removed, within 5 ALE cycles, current  $S-1$  is reapplied. This new  $S-1$  current is also applied until zero crossing occurs. After  $S-1$  slope cross zero, current  $S+1$  is reapplied. After current  $S+1$  is removed,  $S-1$  is applied, and so on. This takes place until time  $T_5$  (and rundown) is completed.

j. During the rundown time, a counter in the Main Controller counts the number of  $S-4$ ,  $S+4$ ,  $S-3$ ,  $S+2$ , and  $S-1$  slopes it takes for each set of slopes to cross zero. This is then used to calculate the 3 least significant digits of the 3468A/B's reading.

**7-F-46. Integrator Offset Compensation.** The A/D Integrator can have offsets which can prevent the  $S+2$  and  $S-1$  slopes from crossing zero. To make sure the slopes will cross zero, the A/D's DAC (Digital to Analog Converter, R401 through R406) is turned on before the  $S+2$  currents are applied. The DAC is used to null out any offsets from the integrator.

**7-F-47.** The correct DAC setting is determined during the time when the  $S+1$  and  $S-1$  currents are applied. These currents are applied after the first set of  $S-1$  slopes have crossed zero (see paragraph 7-F-45, step g). Since both  $S+1$  and  $S-1$  currents have the same amplitude, the  $S+1$  and  $S-1$  slopes should have the same magnitude (i.e. zero crossing should occur at a certain time). If a difference in magnitude is noted by the Main Controller, the DAC is adjusted until the magnitude of the  $S+1$  and  $S-1$  slopes are the same. This is illustrated in Figure 7-F-15. Refer to paragraph 7-F-66 for more information on the DAC.



**Figure 7-F-15. Determining the DAC Setting**

**7-F-48. Rundown Slope Generation.** The  $S-4$  and  $S+4$  slopes are generated the same way it is done for the runup operation (see paragraphs 7-F-38). The only difference is that they only depend on the applied  $S-4$  and  $S+4$  currents, not the input current. The  $S-0$  slope is generated the same way as the  $S-0$  slope in runup (see paragraph 7-F-39). The  $S-3$  and  $S-1$  currents use the same circuitry configuration as the  $S-4$  current (see Figure 7-F-12), but use different resistor values. The resistor values are such that the  $S-3$  current is  $1/10$  the  $S-4$  current and the  $S-1$

current is  $1/1000$  the  $S-4$  current. The  $S+2$  and  $S+1$  currents use the same circuitry configuration as the  $S+4$  current (see Figure 7-F-11). In this case, the resistor values chosen are such that the  $S+2$  currents are  $1/100$  the value of  $S+4$  current and  $S+1$  is  $1/1000$  the value of  $S+4$ .

**7-F-49. A/D Converter and Reference Circuitry.** The A/D Converter Circuitry consists of the A/D Hybrid (U403), A/D Integrator (U401 and associated circuitry), and the Main Controller (U501). Since the Voltage Reference Circuitry (CR401, U405, U404, U402, and associated circuitry) uses part of the A/D Hybrid (for stability purposes) and since it is also used by the A/D Converter, it is considered part of the converter circuitry. Refer to Schematic 3 for the following explanation on the A/D Converter Circuitry.

a. **A/D Hybrid (U403).** The A/D Hybrid, shown in Figure 7-F-16, operates as follows:

1. The A/D Hybrid has, internal to it, various latches, decoders, and a clock generator. The decoders receive control information from the Main Controller, then decode the information and pass the new information to the latches. The latches then transfer the new information to the various switches in the hybrid during each clock pulse. The clock pulses are generated by the clock generator which is synchronized by the ALE clock (from the Main Controller). The hybrid receives all its control information from ports P15 through P17, and P26 and P27 of the Main Controller (U501 pins 32 to 34, and pins 37 and 38). The information is transferred over the A, B, C, D, and E lines (U403 pins 5 through 9) of the hybrid.

2. The  $S-4$ ,  $S+4$ ,  $S-3$ ,  $S+2$ ,  $S-1$ ,  $S+1$ ,  $S-0$ , and  $S+0$  currents are developed using resistors RA2 through RA10 in conjunction with the slope switches.

3. The A/D comparator is also inside the A/D Hybrid and its input is connected to the output of the A/D Integrator. The comparator updates its output during each clock pulse. Since the comparator's output is connected to a latch, the output is transferred to a TTL driver during each clock pulse. The TTL driver is a buffer which connects the output of the latch to the Main Controller.

4. Dependent on the function selected, the hybrid connects the DC/Ohms Input Amplifier's output or the AC to DC Converter's output to the A/D Integrator's (U401) input resistor (RA1 in U403). This is done by the input switches inside the hybrid.

b. **A/D Integrator (U401 and associated circuitry).** The A/D Integrator consists of an amplifier (U401) with capacitor feedback (C410). Since the amplifier is inverting, the output slopes of the integrator will be positive for negative input currents (and vice versa).

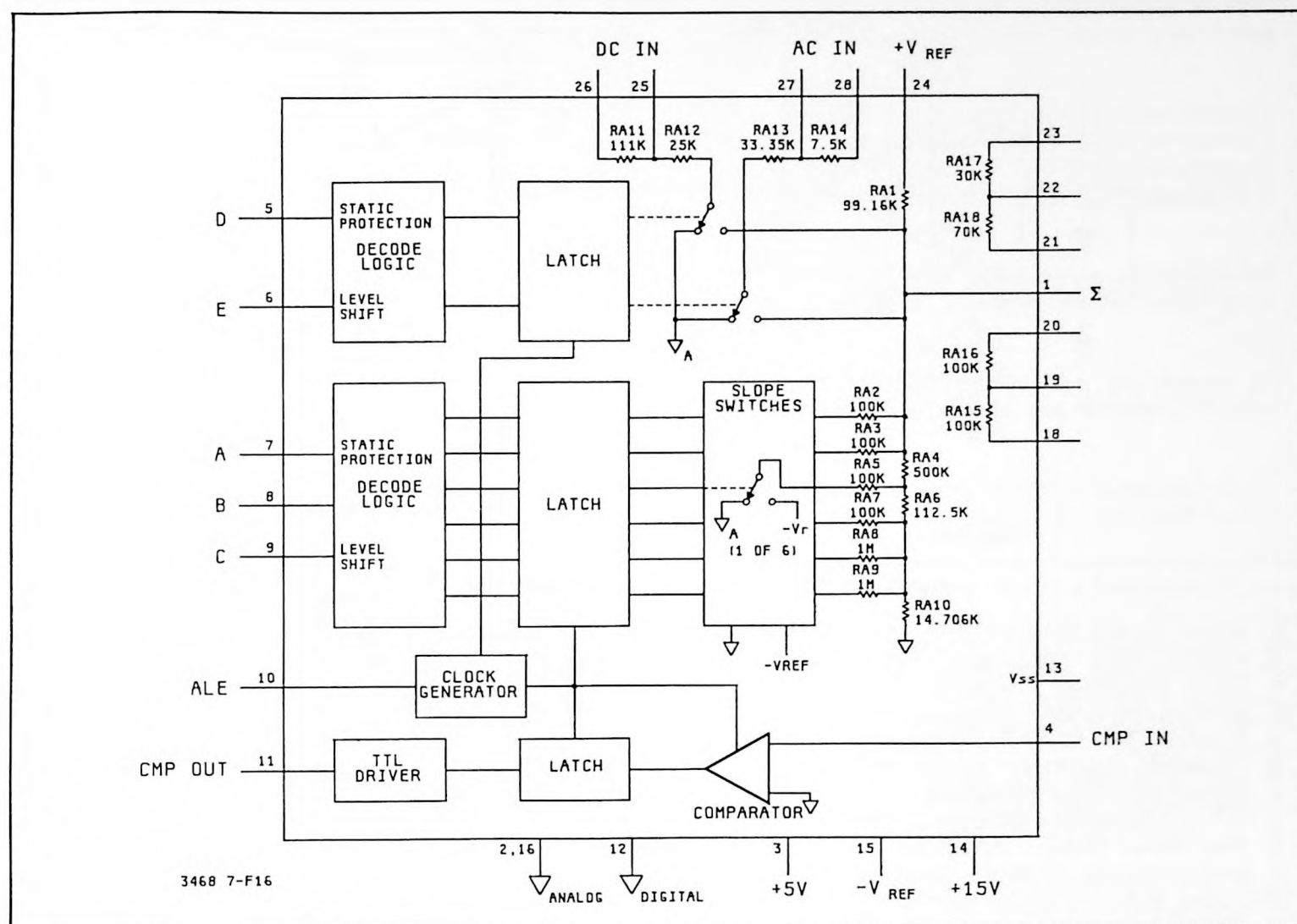


Figure 7-F-16. A/D Hybrid (U403)

c. **Main Controller (U501).** The Main Controller controls the operation of the A/D Converter and the instrument. This includes the control of the runup and run-down operation, and selecting the correct currents (S-4, S+4, etc.). Refer to paragraph 7-F-52 for more information on the Main Controller.

d. **Voltage Reference.** The Voltage Reference provides three stable reference voltages: -10V, +10V, and a buffered -10V. The circuitry, shown in Figure 7-F-17, is explained as follows:

1. The -10V reference voltage is used by the A/D Hybrid (U403) to develop stable and accurate S-4, S+4, S-3, etc. currents. The reference voltage is developed by non-inverting amplifier (U405) using feedback resistors in U403 and a 6.9V reference diode (zener diode CR401). The reference diode is connected to the amplifier's positive terminal and determines the stability of the reference voltage. The feedback resistors for U405 are in U403 for good stability.

2. The buffered -10V is used by the A/D Hybrid as a stable -10V power supply. The voltage is

developed by X1 gain non-inverting amplifier U404 and the -10V reference voltage.

3. The +10V reference voltage is used by the A/D Hybrid (in conjunction with the -10V reference) to develop the S-4, S+4, S-3, etc. currents. The +10V reference voltage is also used by the Ohms Current Source to develop a stable ohms current (see paragraph 7-F-21). The reference voltage is developed using inverting amplifier U402 and feedback resistors in U403.

#### 7-F-50. 3468A/B Control Logic Circuitry

7-F-51. The 3468A/B Control Logic Circuitry controls the operation of the whole instrument, including front panel and remote operation. The major circuitry is the Main Controller Circuitry, consisting of a CPU (U501) and a Control ROM (U502). The operation of the Control Circuitry is described in the following paragraphs. Unless otherwise specified, refer to Schematic 3 for the explanation. The circuitry is described as follows:

- a. Main CPU (U501) Circuitry - paragraph 7-F-52.
- b. Control ROM (U502) - paragraph 7-F-53.



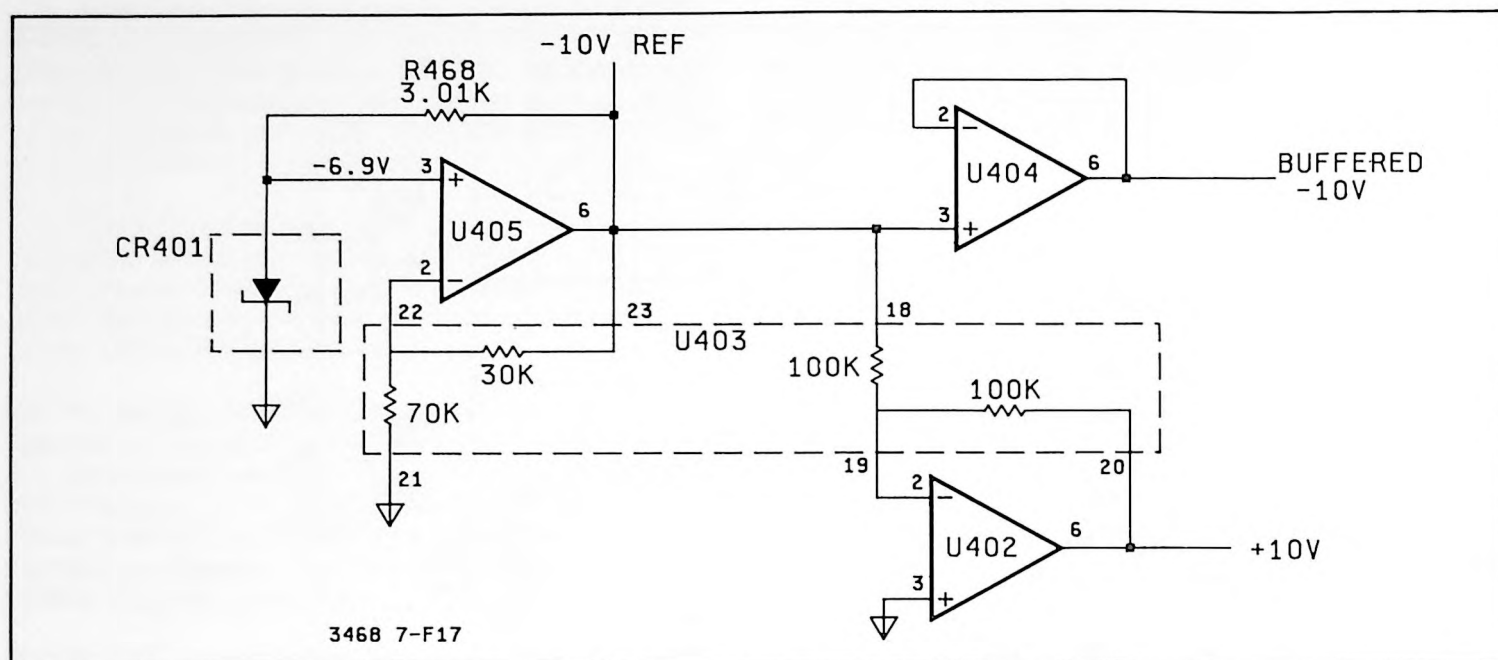


Figure 7-F-17. 3468A/B Simplified Reference Circuitry

- c. Power-On and Reset Circuitry - paragraph 7-F-54.
- d. CMOS RAM - paragraph 7-F-55.
- e. RAM Addressing - paragraph 7-F-56.
- f. Reading the RAM - paragraph 7-F-57.
- g. Sending Data to RAM - paragraph 7-F-58.
- h. Keyboard Operation - paragraph 7-F-60.
- i. Display Operation - paragraph 7-F-61.
- j. HP-IL Operation - paragraph 7-F-62.
- k. Rear Panel Switch - paragraph 7-F-63.
- l. A/D Converter Control - paragraph 7-F-64.
- m. Input Hybrid Control - paragraph 7-F-65.
- n. Digital to Analog Converter Operation - paragraph 7-F-66.

**7-F-52. Main CPU (U501) Circuitry.** The operation of the CPU and associated circuitry is as follows:

a. The CPU has an internal 128 bytes of RAM memory and a clock. The frequency and stability of the clock is determined by 6.003 MHz crystal Y501.

b. The Data Lines (D0 to D7) from the CPU are used as both Data Lines and the lower 8 bits of the Address Lines (A0 to A7). This is done by multiplexing the lines. The Address Lines are used to address the Control ROM, CMOS RAM, and the HP-IL Chip. The Data Lines send and receive data between the CPU and the Control ROM, CMOS RAM, and HP-IL Chip. The ALE (Address Latch Enable) line goes low to latch the lower 8 Address bits on U508. The Address bits are then sent to the Control ROM, CMOS RAM, and HP-IL Chip.

c. Other lines from the CPU are bi-directional Ports. The ports are used to control the A/D Converter Hybrid (U403) and Input Hybrid (U102), send information to the display, and send and receive data to the keyboard. Some ports (P20 through P23) are used as the upper Address bits, A8 through A11).

**7-F-53. Control ROM (U502).** The Control ROM is addressed when its CE line (Chip Enable at U502 pin 20) is low. The low comes from the CPU's PSEN line (Program Store Enable at U501 pin 9). Address A0 to A7 comes from latch U508. Address bits A8 to A11 comes from Ports P20 to P23 (U501 pins 21 to 24). Address bit A12 comes from Port P14 (U501 pin 31) of the CPU. When the ROM is addressed and enabled, data from the ROM is transferred to the Data Lines.

**7-F-54. Power-On and Reset Circuitry.** The Power-On and Reset Circuitry is used to reset the CPU after the 3468A/B is turned on, when the front panel TEST/RESET button is pressed, and if the CPU inadvertently goes to a non-operational state. The circuitry operates as follows:

a. **Power-On Circuitry.** Refer to Figure 7-F-18 or Schematic 3. The Power-On Circuitry resets the CPU when the 3468A/B is turned on and when the >7V power supply (raw supply for the +5V supply) is low. The step by step operation is as follows:

1. When the 3468A/B is turned on, the positive input of comparator U550A goes high after the >7V power supply comes up.

2. Since the negative terminal of U550A is connected to BT551, the output of the comparator attempts to go high and charges capacitor C551. The output goes high since the comparator has an open collector output and a pull-up resistor is connected between the CPU's RESET line (output of U550A) and +5V (the resistor is internal to the CPU).

3. During the charge time, the RESET line rises from a low level until the capacitor is charged to a high level.



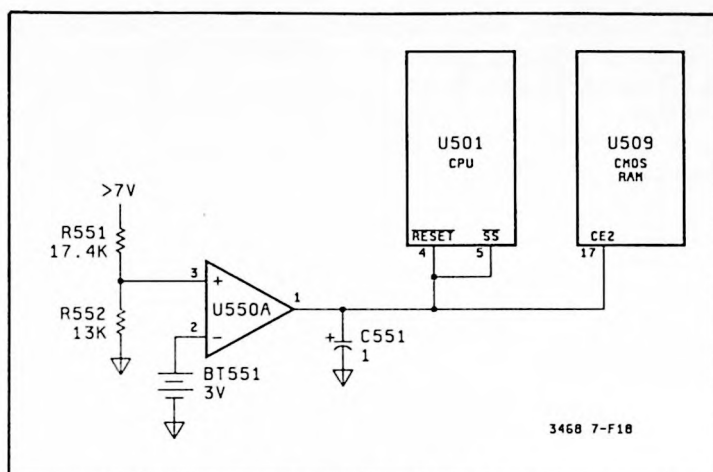


Figure 7-F-18. Power-On Circuitry

4. The  $\overline{\text{RESET}}$  line goes high and the CPU resets and turns on. The 3468A/B is now in its turn-on state.

5. As long as the  $\overline{\text{RESET}}$  line is low, the CPU's SS (Single Step) line is low (the line is connected to the  $\overline{\text{RESET}}$  line). Holding the SS line low, forces the  $\overline{\text{PSEN}}$  line high and prevents the CPU from reading the Control ROM before the ROM is initialized.

6. When the  $\overline{\text{RESET}}$  line is low, the CE2 line of the CMOS RAM (U509) is also low and disables the RAM (see paragraph 7-F-59).

7. The CPU is also reset when the >7V power supply goes low. A low power supply sets the positive input of U550A low which makes the U550A's output low. This resets the CPU.

b. **Reset Circuitry.** Refer to Figure 7-F-19 or Schematic 3. The Reset Circuitry is used to reset the CPU when the TEST/RESET button is pressed or if the CPU inadvertently goes to a non-operational state. The step by step operation is as follows:

1. During normal operation, counter U504 is continuously incremented by the ALE clock.

2. The counter is reset by the Q1 output of latch U507. The latch receives its data from Port 20. Since the Q1 output of the latch is also connected to the keyboard, the counter is reset as long as the keyboard is scanned (see paragraph 7-F-60). The reset pulse is developed by C503, CR501, and R502.

3. If the TEST/RESET button is pressed or the CPU goes to a non-operational state, the keyboard scanning is stopped.

4. Since the ALE clock is still operating, the counter keeps incrementing for about 1.3 seconds.

5. After the 1.3 seconds, the Q20 output of U504 goes high. This is because the counter is not being reset.

6. The Q20 output is connected to the negative terminal of comparator U550B. Since the positive terminal of U550B is at +3.3V (from the display), U550B's output goes low. This brings the  $\overline{\text{RESET}}$  line low.

7. The ALE clock continues to increment the counter and after 1.3 seconds the Q20 output goes low.

8. With the Q20 output low, the output of U550B attempts to go high and charges C551 (see step a-2).

9. Once the capacitor is charged to the high level, the CPU then resumes operation. The 3468A/B is now in its turn-on state.

**7-F-55. CMOS RAM.** The CMOS RAM is used to store the 3468A/B'S Calibration Constants. The following paragraphs explain how the RAM is addressed, how data (constants) is read from the RAM, and how new data (new constants) is sent to the RAM. This is done using the RAM's Address, Input, and Output Lines. The Address Lines are connected to the CPU's lower 8 Address bits (A0 to A7). The RAM's input and output lines, (D1 to D4 and DO1 to DO4 respectively), are connected to each other and to the DO to D3 Data Lines.

**7-F-56. RAM Addressing.** The RAM can only be addressed as long as line CE2 (Chip Enable 2 at U509 pin 17) is high. The line is high when the 3468A/B is turned on.

**7-F-57. Reading the RAM.** The RAM can be read under the following conditions.

a. Line OD (Output Disable at U509 pin 18) must be low. It is low when the RD Line (Read at U501 pin 8) is low.

b. Line  $\overline{\text{CE1}}$  must also be low. It receives the low from one section of the CMOS latch U505 (pin 6). The latch transfers data from Port P23 during each ALE cycle.

c. Once the previous conditions are met (the RAM is addressed) and line CE2 is high, data from the RAM is transferred to the Data Lines.

**7-F-58. Sending Data to RAM.** The RAM can receive new Data when its R/W line (Read/Write at U509 pin 20) is low. This can only happen if the 3468A/B's Cal Switch (located at the rear panel) is on (down) and the WR line of the CPU (Write at U501 pin 10) is low. When the CAL Switch is on (down), it connects the WR line of the CPU to the R/W line of the CMOS RAM. When the WR line is low, the RAM can then receive new data.

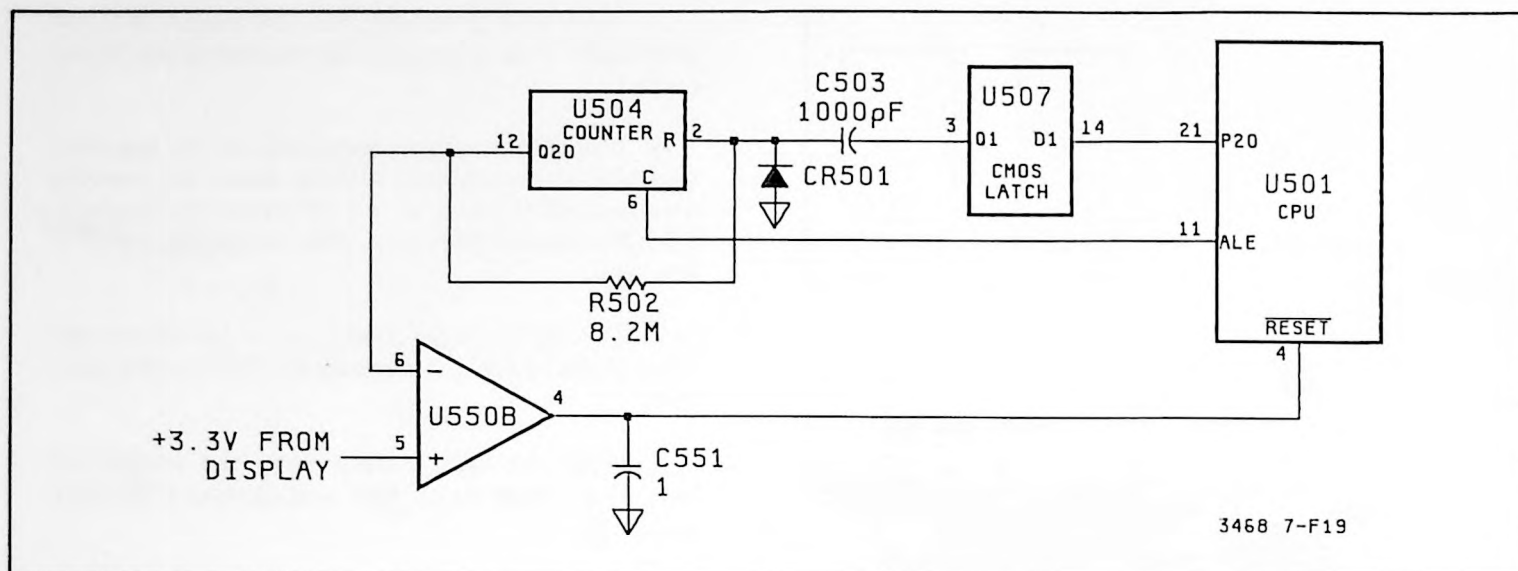


Figure 7-F-19. Reset Circuitry

7-F-59. Since the 3468A/B's Calibration Constants are stored in the CMOS RAM, the constants must remain in the RAM when the 3468A/B is turned off (or power removed). This is done by battery BT551. In addition, the RAM should not see any possible write commands (R/W low) during the time that power is removed. The RAM must be disabled. This is because a write command may erase some calibration constants. The RAM is disabled by comparator U550A (part of the CPU's power on). The operation is as follows:

a. As long as the 3468A/B is on, the RAM gets its supply voltage from the +5V power supply through diode CR550.

b. When power is off, the RAM gets its supply voltage from battery BT551 through diode CR551. The battery voltage is used for data retention.

c. After turning power off, the RAM is disabled by setting Line CE2 low. This is done by comparator U550A. The comparator senses a low (or no >7V) from voltage divider R551 and R552. Since U550A's negative terminal is at the battery voltage, the output of U550A discharges C551 before the supply goes off. This makes Line CE2 low and disables the RAM.

**7-F-60. Keyboard Operation.** The Keyboard's pushbuttons are connected in a 4X4 matrix and are continuously scanned by the CPU. The operation is as follows:

a. One side of the matrix is connected to Ports P10 to P13 of the CPU (U501 pins 27 to 30) and the other side is connected to the Q1 to Q4 outputs of CMOS latch U507 (U507 pins 3 to 6). The latch receives its input from Ports P20 to P23 (U501 pins 21 to 24) and transfers data each time the CPU's PROG line goes low.

b. Before scanning starts, the Q1 to Q4 outputs of U507 and Ports P10 to P13 of U501 are set high. When

scanning starts, starting with the Q1 output, each output goes sequentially low.

c. During the time that the keyboard is scanned, the CPU determines which one and if any of Ports P10 to P13 are low. A low on P10 to P13 is used to determine the button pressed. For example, the SRQ button is pressed and turns the corresponding keyboard SRQ switch on. This connects Port P11 to output Q4 which makes P11 low when Q4 is low. Since the CPU knows when it sets Q4 low and also knows when P11 is low, the pressed button is determined.

**7-F-61. Display Operation.** The 3468A/B Display is an alphanumeric display with 12 annunciators. The CPU sends serial data to the Display Circuitry which in turn does all the necessary decoding of the data (to display readings, etc.). The operation is as follows:

a. With line PWO high, the CPU can send new data to the Display Circuitry. Data is in serial form and is sent on the INA line (U505 pin 4). For the Display Circuitry to receive and decode the data, the other display lines have to send certain information to the circuitry. This is as follows:

1. The Display Circuitry requires two clock inputs to receive data,  $\phi 1$  and  $\phi 2$ . The inputs come from latch U505 (pin 3) and Port P25 for clock inputs  $\phi 1$  and  $\phi 2$ , respectively.

2. The ISA line (U505 pin 5) is used to give instructions to the Display Circuitry.

3. The SYNC line (U505 pin 6) is used to tell the Display Circuitry when to look for instructions.

b. With line PWO (from Port P24 of the CPU at U501 pin 35) low, the Display circuitry operates without receiving any data from the CPU. The circuitry can operate



in this mode since it has an internal clock (capacitor C501 is the frequency reference). With the circuitry in the internal mode, no updating of the display is done. Line PWO is controlled by the CPU.

**7-F-62. HP-IL Operation.** All interfacing between the CPU and the Hewlett-Packard Interface Loop (HP-IL) is accomplished by the HP-IL Chip (U503) and isolation transformer T503. The transformer is used to transfer data between the HP-IL Chip and the loop. The circuitry operates as follows.

a. The HP-IL Chip generates its own clock signal using internal circuitry in conjunction with inductor L501 and C504.

b. When U503 is addressed (by the CPU) and its WR (Write) line is low, data from the CPU is sent over the Data Lines to U503. Line WR gets its low from the CPU's WR line. With the CPU WR line low, its RD (Read) line is high (which makes U503's RD line high). Depending on the Register selected (RS0 to RS2 at U503 pins 5 to 3, which are the A0 to A2 Address Lines of the CPU), U503 interprets the data as the interface state (Talker, Listener, etc.) or a frame of data to be sent.

c. When U503 is addressed (by the CPU) and its RD line is low, U503 is enabled to send data to the CPU over the Data Lines. Line RD gets its low from the CPU's RD line. Depending on the Register selected (RS0 to RS2, see previous step), the data may be a frame which was received or status about the state of the interface.

d. The CPU continuously checks (for HP-IL data) and updates U503.

**7-F-63. Rear Panel Switch.** The Rear Panel Switch (S501) is an eight section DIP switch used to select the 3468A/B's Signature Analysis (SA) Routines, set the Power SRQ Status Bit, set the 3468A/B to the talk-only mode, set the multimeter to the selected power line frequency, and to enable calibration. Except for the calibration operation (it is explained in Section IV of this manual), the purpose and operation of the switches is as follows:

a. **SA1 and SA2.** The 3468A/B has two SA (Signature Analysis) routines. SA1 and SA2. SA1 is selected by connected the cathode of CR520 to ground and SA2 is selected by connecting jumper JM510 to ground. When SA1 is selected, Address line A12 of the ROM is held low and places the ROM and CPU to the SA1 code location at power on reset. When SA2 is selected, the CPU's interrupt line is held low and will signal the CPU to go to the SA2 routines at power on reset.

b. **Power-On SRQ.** This switch holds the A6 line of the HP-IL Chip low. This line determines the value of bit 7 of the SRQ Mask (see this manual's Section III for information on the Power SRQ Bit).

c. **Talk-Only Mode.** In this case, the switch holds the HP-IL Chip's A7 line low and the 3468A/B is placed into the talk-only mode by the chip (refer to this manual's Section III for information on this mode).

d. **Power Line Frequency (50Hz/60Hz).** This switch holds the T0 input line (U501 pin 1) of the CPU low. The CPU will then select the A/D Converter's Integration Time for the selected power line frequency (1/60 second for 60Hz or 1/50 second for 50Hz, etc.).

**7-F-64. A/D Converter Control.** The A/D Converter receives control data from the CPU's Ports P15 to P17 (U501 pins 32 to 34), P26 (pin 37), and P27 (pin 38). The data is used to select the various slopes (see paragraph 7-F-49 step a) in the converter. The output of the A/D Converter (CMP, the Comparator Output) is applied to the T1 input of the CPU (at U501 pin 39). The ALE output is used as the A/D converter's clock. Refer to paragraph 7-F-31 for more information on the A/D operation.

**7-F-65. Input Hybrid Control.** The control lines to the Input Hybrid (U102) are: Data, Mode, and Clock. The Data line comes from the Q3 output of latch U505 (pin 5), the Mode line comes from Port P10 (U501 pin 27), and the Clock comes from Port P26 (U501 pin 37). The lines do the following.

a. When the Clock input (U102 pin 24) is low, no data is transferred into the hybrid.

b. When the clock input makes a transition from low to high, the following happens:

1. When the Mode input (U102 pin 25) is low, data on the Data line (U102 pin 26) is transferred into the hybrid (into an internal shift register).

2. When the Mode input is high, the data in the hybrid (in its shift register) is used to set-up the switches in the hybrid.

**7-F-66. Digital to Analog Converter Operation.** The 3468A/B's A/D Converter requires a certain offset voltage (see paragraph 7-F-46 for more information). This offset is applied to the negative input of the A/D Integrator (U401) and comes from the Digital to Analog Converter (DAC). The offset voltages are developed by resistors R401 to R406, which are selected by CMOS latches U505 and U507. Each time latch U505 is clocked by the ALE and latch U507 is clocked by the CPU's PROG line, the output of the latches is either high or low. This depends on the position (high or low) of Ports P20 to P23. The outputs in conjunction with resistors R401 to R406 then generate a certain offset voltage.

**7-F-67. Power Supplies**

**7-F-68. General.** The 3468A/B has three power supplies: +15V, -15V, and +5V (plus an unregulated supply,



>7V). All power supplies use transformer T730 as the main ac power source. If the 3468A/B has the battery option (Option 001), the Battery Charger Circuitry (see Paragraph 7-F-72) supplies the raw voltages for the power supplies when ac power is removed. Refer to Schematic 4 for the following explanation on the power supply circuitry.

**7-F-69. +5V and >7V Supplies.** A full-wave rectifier, consisting of CR703 and CR704, develop the raw (unregulated) voltage for the +5V power supply. The voltage is the >7V supply and comes from the Battery Charger when ac power is removed. The +5V regulated voltage is developed by voltage regulator U701. Breakdown diode CR712 is used for overvoltage protection. Capacitor C705 and C731 are filter capacitors. Diode CR707 normally does not conduct, but will conduct if the +15V power supply goes below +5V. This is used to protect the Input Hybrid, U102, if the +15V supply goes low. Temperature sensitive resistor RT705 is used to protect supplies from excessive output currents. The protection circuitry operates as follows:

- a. If the output current of the +5V and >7V is excessive, RT705 heats up.
- b. Since RT705 has a positive temperature coefficient, its resistance increases to a large value due to high temperature.
- c. The high resistance causes most of the supply voltage to drop across RT705, in effect shutting down the supplies.
- d. The large resistance value remains until RT705 cools down (power supply draws normal current).

**7-F-70. +15V Supply.** A voltage doubler circuit, consisting of C741, C703, CR701, and CR702, is used to develop the raw (unregulated) voltage for the +15V supply. The voltage comes from the Battery Charger when ac power is removed. The voltage doubler circuit develops the raw voltage by charging capacitor C741 during the negative cycle of the ac power source (T730). The capacitor is charged through diode CR702 (CR701 does not conduct at this time). During the positive ac cycle, CR701 conducts and rectifies the ac voltage to dc. The resultant dc voltage is the positive voltage from the secondary of the power transformer (between pins 11 and 13 of T730) plus the charge on capacitor C741. This makes the resultant voltage approximately twice the peak ac voltage (+20V). Diode CR752 prevents any negative voltages from being applied to the positive side of C741 (which may happen at turn on). The regulated +15V comes from voltage regulator U703. Breakdown diode CR750 and CR711 are used for overvoltage protection. Capacitor C704 is a filter capacitor. Temperature sensitive resistor RT707 is to protect the supply from excessive output currents (see Paragraph 7-F-69 step a).

**7-F-71. -15V Supply.** The -15V Supply is a mirror image of the +15V Supply. Refer to the explanation on the +15V Supply (see previous paragraph) for the explanation on the -15V Supply. Keep in mind that the currents and voltages are opposite in polarity.

#### **7-F-72. Battery Charger Circuitry (Option 001)**

7-F-73. The Battery Charger Circuitry is located on the A3 assembly and does the following:

- a. **Battery Charging (Power Switch Off).** The Battery is charged (if it needs charging) with a typical charge current of 400mA.
- b. **Battery Charging (Power Switch On).** The Battery is charged (if it needs charging) with a typical current of 130mA.
- c. **Battery Only Operation.** The battery supplies the power for the DC to DC Converter which supplies the raw (unregulated) voltages for the 3468A/B's +5V, +15V, and -15V power supplies.

7-F-74. The Battery Charger Circuitry consists of a Battery, Battery Charger, Voltage and Current Sensing Circuitry, and a DC to DC Converter. The following paragraphs explain how the different circuitry operates. Refer to Schematic 5 (and 4) for the explanation.

**7-F-75. Battery Charging (Power Switch Off).** With the power switch off and ac power applied to the 3468A/B, the Battery Charger operation is explained in the following steps. Refer to Figure 7-F-20 (Simplified Schematic Of The Battery Charger) for the explanation.

- a. The output from transformer T730 (coming through pins 8 and 16 of P701) is connected to full-wave rectifier CR901 and CR902. The dc output of the diodes is used as the battery charger power supply when ac power is connected to the 3468A/B.

- b. Comparator U902A (in conjunction with Q901 and Q902) determines if battery BT901 needs charging. Comparator U902A in conjunction with U902B also determines the maximum allowable charge current. The operation is as follows:

1. If the battery voltage is less than approximately 7.1V (the voltage decreases as temperature increases), the battery needs to be charged.

2. The battery voltage is divided down by divider R924, R904, R903, and RT922. The resultant voltage drop across R903 is applied to the negative terminal of U902A.

3. The positive terminal of U902A is at +2.5V, which comes from voltage regulator U901. If the negative terminal of U902A is below +2.5V, its output goes high. This is because the comparator

operates as an amplifier. The high output turns Q902 on harder which turns Q901 on harder, supplying more current to the battery.

4. If the positive terminal of U901A goes above +2.5V, its output goes lower and turns Q901 and Q902 on less hard (the battery receives a smaller charge current). When the battery is completely charged, there is still a trickle charge current of approximately 5mA. The current prevents the battery from discharging itself and to maintain the battery voltage at approximately 7.1V.

5. Diode CR904 is used to supply the power for U902 when ac power is connected to the 3468A/B and CR905 is used to supply the power (from the DC to DC Converter) when ac power is disconnected. Diode CR905 has to supply power to U902 since U902 is also used when power is disconnected.

c. Comparator U902B is used to determine the maximum battery charge current and operates in conjunction with U902A. The operation is as follows:

1. The negative terminal of U902B is connected to ground.

2. The positive terminal of U902B is connected to summing resistors R908, R909, and R910. Resistors R908, R909, and R910 are connected to the -15V power supply, to +2.5V, and to R740 (at

the center tap of T730), respectively. The voltage drop across R740 is directly proportional to the sum of the battery charge current and the +5V supply current.

3. With the 3468A/B's power switch off, the -15V supply is at zero volts and the +5V power supply current is zero. At this time, the voltage drop across R740 depends on only the current drawn by the battery charge circuitry. Since the negative terminal of U902B is at zero volts (ground potential), the positive terminal must also be at zero volts (for normal operation). This is true when the voltage drop across R740 is at a certain value. The voltage drop has the correct value when the battery charge current is approximately 400mA. Comparator U902B in effect forces its positive terminal to zero volts by controlling the amount of battery charge current (using Q901 and Q902).

4. With the 3468A/B's power switch on, the -15V and +5V power supplies are now on. At this time, the voltage drop across R740 depends on the current drawn by the battery charge circuitry and the +5V supply. In order for the positive terminal of U902B to be at zero volts, the voltage drop across R740 must now be different (because the -15V and +5V power supplies are now on). The voltage drop across R740 is now correct when the battery charge current is at approximately 130mA.

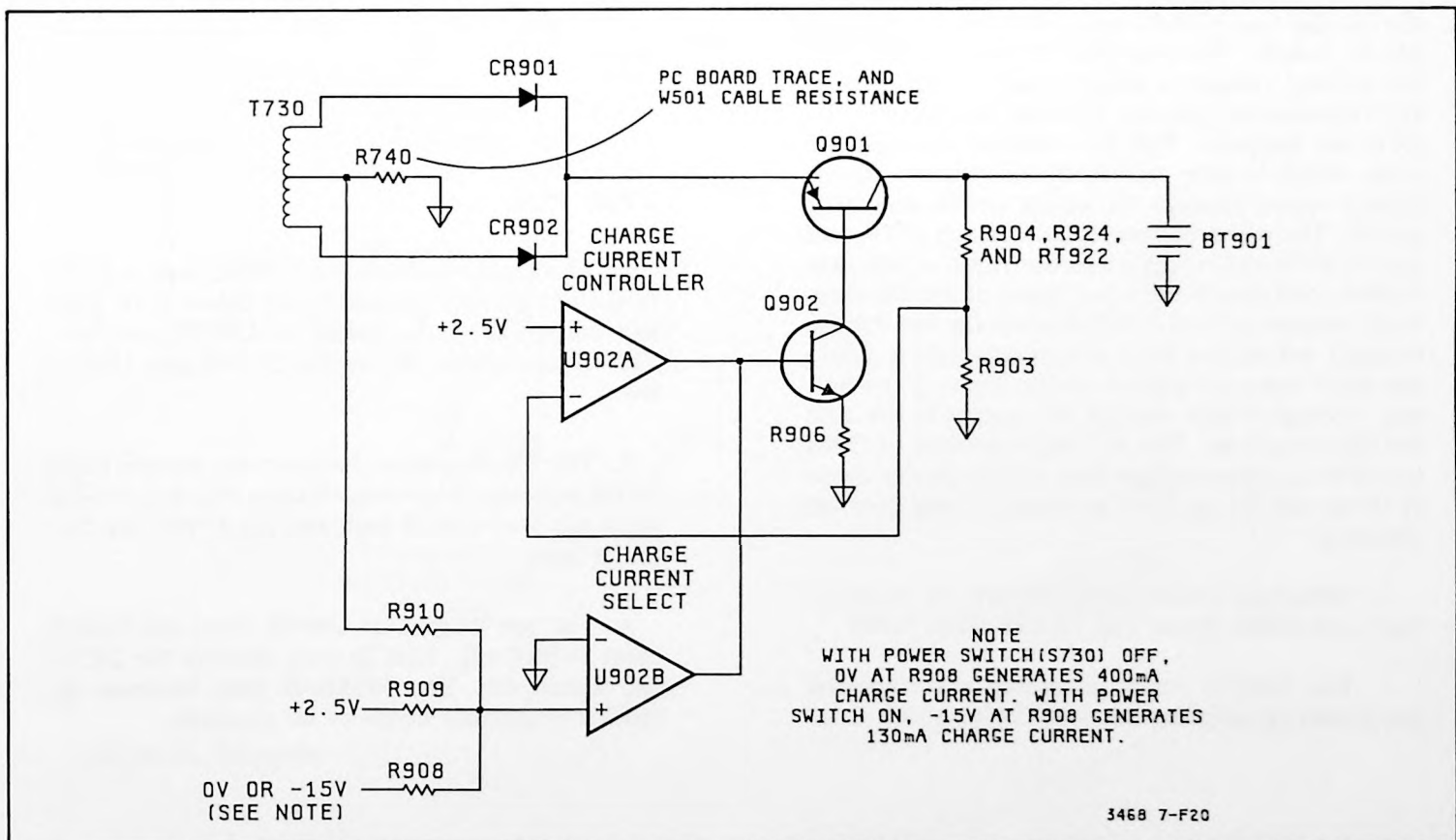


Figure 7-F-20. Simplified Schematic Of The Battery Charger



**7-F-76. Battery Only Operation.** In this mode, the DC to DC Converter generates the raw power supply voltages for the 3468A/B's power supplies. Three conditions must be met for the converter to operate: the ac power source is disconnected from the multimeter, the instrument is on (power switch on), and the battery voltage must be high enough. The following steps explain the operation of the DC to DC Converter. Refer to Figure 7-F-21 (simplified schematic of the DC to DC Converter) for the explanation.

a. When power is disconnected from the 3468A/B, the condition is sensed by comparator U902D and turns the DC to DC Converter on.

1. As long as ac power is applied to the 3468A/B, the positive terminal (pin 7) of U902D is at a level larger than +2.5V. The voltage at U902D pin 7 comes from one of the ac lines of T730 (P701 pin 16), after the ac voltage is rectified by CR903 and divided down by divider R901 and R902. Under normal conditions, the voltage must be above +2.5V, since the negative terminal of U902D is at +2.5V. This makes the output of U902D high and prevents the DC to DC Converter from operating.

2. When ac power is disconnected, the positive terminal of U902D goes to zero. The result is that the output of comparator U902D, which is connected to one input of Nor gate U903B, goes low.

3. The other input of U903B is also low because the SR flip-flop (U903C and U903D) is set (U903D pin 11 is low). The flip-flop is used to make sure the battery voltage is large enough for the DC to DC Converter to operate. The flip-flop is set by two different methods. The first method is a positive pulse which is generated from the battery voltage (which comes through the power switch and P701 pin 9). The pulse is developed through C904 and across R914 and is applied to one input of nor gate U903A, and also to the S (set) input of the flip-flop. In the second method, U902D (when the line voltage is high), will do the same as a positive pulse. Since the other input of U903A is also high, if the battery voltage is high enough, its output is low and the flip-flop is set. The RC time constant of C904 and R914 assures enough time for the power supply (from the DC to DC Converter) to stabilize the circuitry.

4. With both inputs to U903B low, its output is high and resets (turns on) CMOS timer U905.

5. The CMOS timer generates a rectangular waveform (at approximately 28KHz) which is in-

verted by gate U904A (U904A is a Nor gate connected as an inverter). The frequency of the timer is determined by R915, R916, CR911, and C911.

6. When the output of U904A is low, the outputs of Nor gates U904B, C, and D (which are also connected as inverters) are high. The high turns on transistor Q905 which turns on transistor Q904. Current then flows from the battery into transformer T901.

7. When the output of U904A is high, the outputs of U904B, C, and D go low and turn Q904 and Q905 off. This turns the current flow through T901 off. A high output of U904A also turns on Q903. This is used to turn Q904 off quicker.

8. With Q904 on and current flow to T901 increasing, the magnetic field of T901 expands and voltage is induced into its secondary. With Q904 off and current flow to T901 disabled, the magnetic field of T901 collapses and voltage of opposite polarity is induced into its secondary. These voltages are rectified by bridge rectifier CR912, CR913, CR914, and CR915 and also by bridge rectifier CR916, CR917, CR918, and CR919. The resultant dc voltages are the raw voltages for the 3468A/B's power supplies.

b. When the battery voltage is low (less than approximately +5.5V), the DC to DC Converter turns off. The operation is as follows:

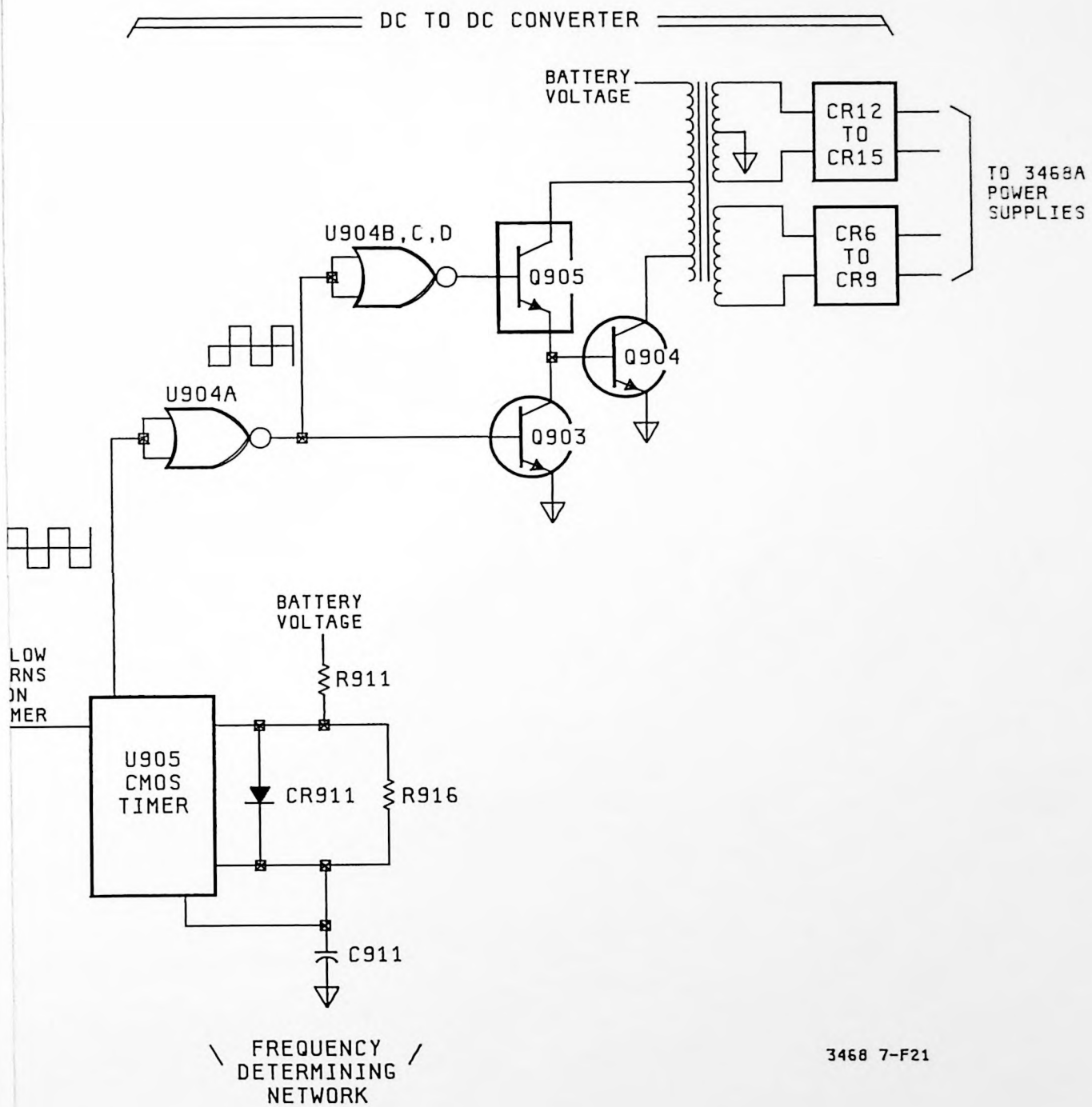
1. The battery voltage divided down by voltage divider R911 and R912 and applied to the positive terminal of comparator U902C. The terminal is normally above +2.5V and makes the output of U902C high.

2. The negative terminal of U902C is at +2.5V. When the positive terminal goes below 2.5V (battery voltage low), the output of U902C goes low. This in turn makes the output of Nor gate U903A low.

3. The flip-flop then changes state (output high) which generates a low output from Nor gate U903B (with pin 5 of U903B high and pin 6 low, the output is low).

4. The low output of U903B turns the CMOS timer (U905) off. This in turn disables the DC to DC Converter. The 3468A/B then becomes inoperative (battery needs to be charged).





DC to DC Converter

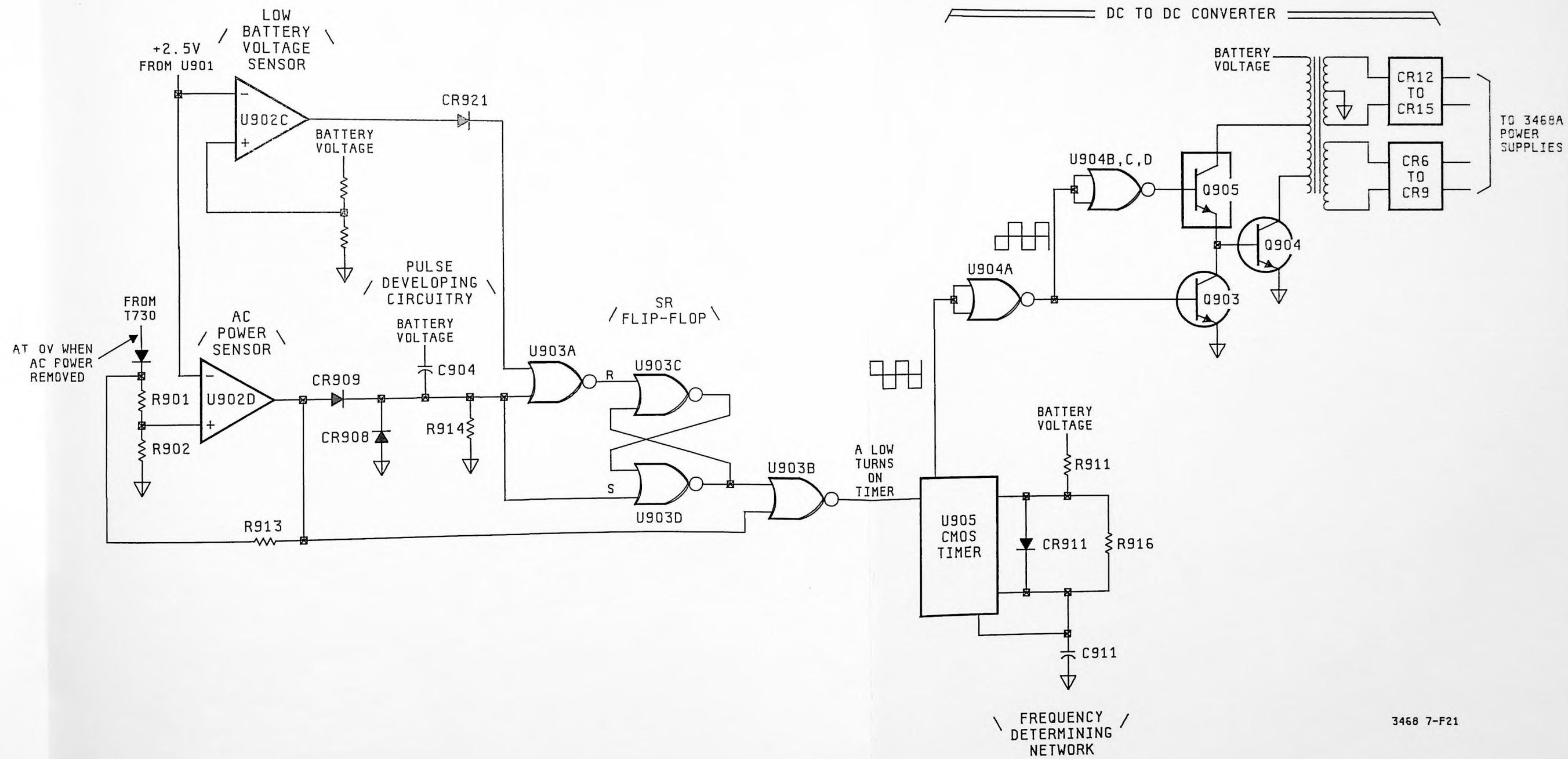
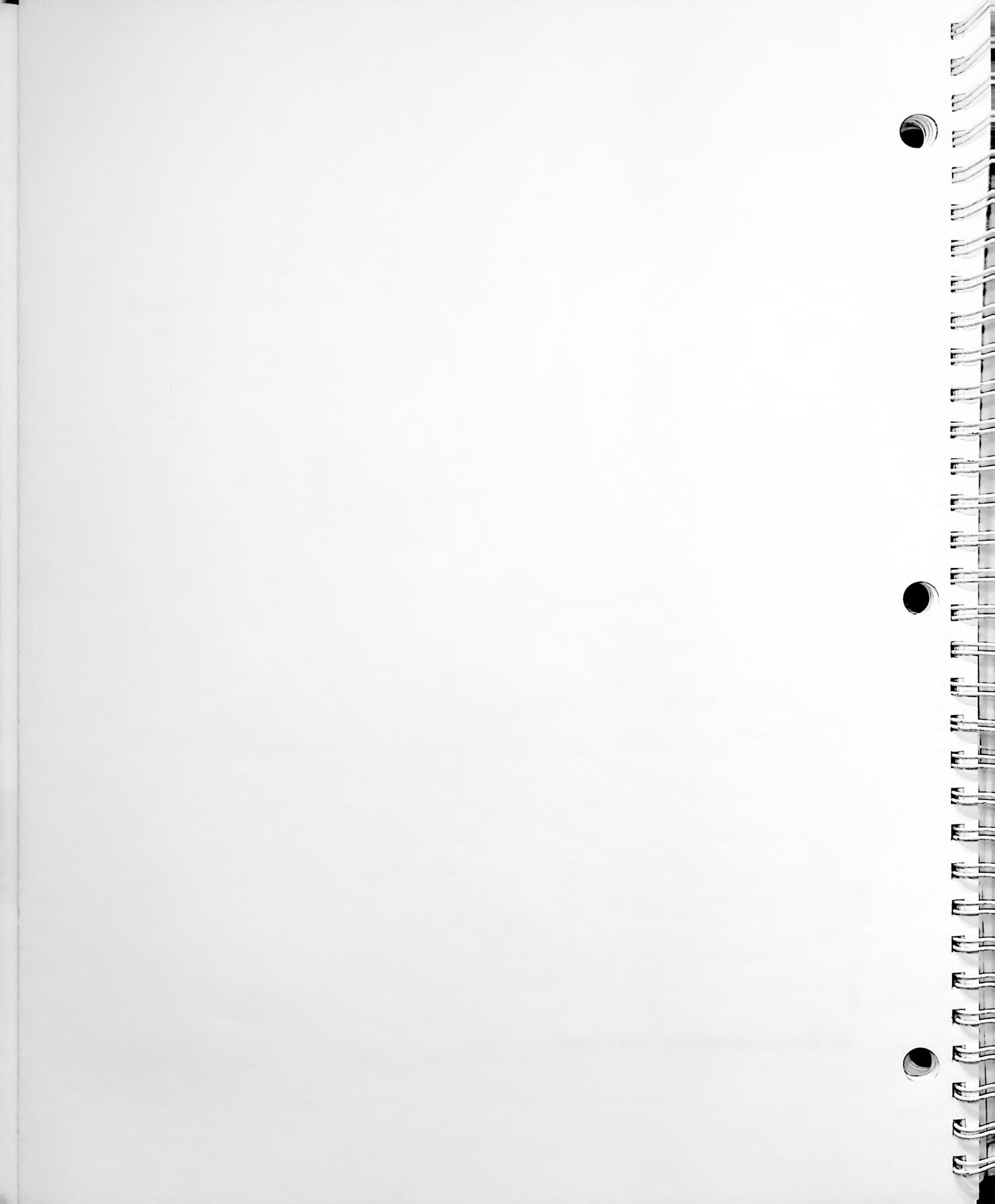


Figure 7-F-21. Simplified Schematic Of The DC to DC Converter





# SERVICE GROUP G

## SCHEMATICS

### 7-G-1. INTRODUCTION

7-G-2. This Service Group has the 3468A/B's Block

Diagram and Schematics. In addition, general schematics notes are also included to gain an understanding on how to use the schematics.

### GENERAL SCHEMATIC NOTES

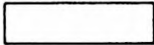



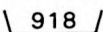


1. RESISTANCE IN OHMS, CAPACITANCE IN MICROFARADS, INDUCTANCE IN MICROHENRIES UNLESS OTHERWISE NOTED.
2. ASTERISK DENOTES A FACTORY-SELECTED VALUE. VALUE SHOWN ON SCHEMATIC IS TYPICAL.
3.  ENCLOSURES FRONT PANEL MARKING.
4.  ENCLOSURES REAR PANEL MARKING.
5.  CIRCUIT ASSEMBLY BORDERLINE.
6.  OTHER ASSEMBLY BORDERLINE. ALSO USED TO INDICATE MECHANICAL INTERCONNECTIONS (GANGING).
7.  DENOTES WIRE COLOR CODE. CODE USED IS SAME AS THE RESISTOR COLOR CODE. FIRST NUMBER IDENTIFIES THE BASE COLOR, SECOND NUMBER IDENTIFIES THE WIDER STRIPE, THIRD NUMBER IDENTIFIES THE NARROWER STRIPE.  
E.G.  DENOTES WHITE BASE, BROWN WIDE STRIPE, GRAY NARROW STRIPE.
8.  DENOTES GROUND ON PC ASSEMBLIES.

Figure 7-G-1. General Schematic Notes

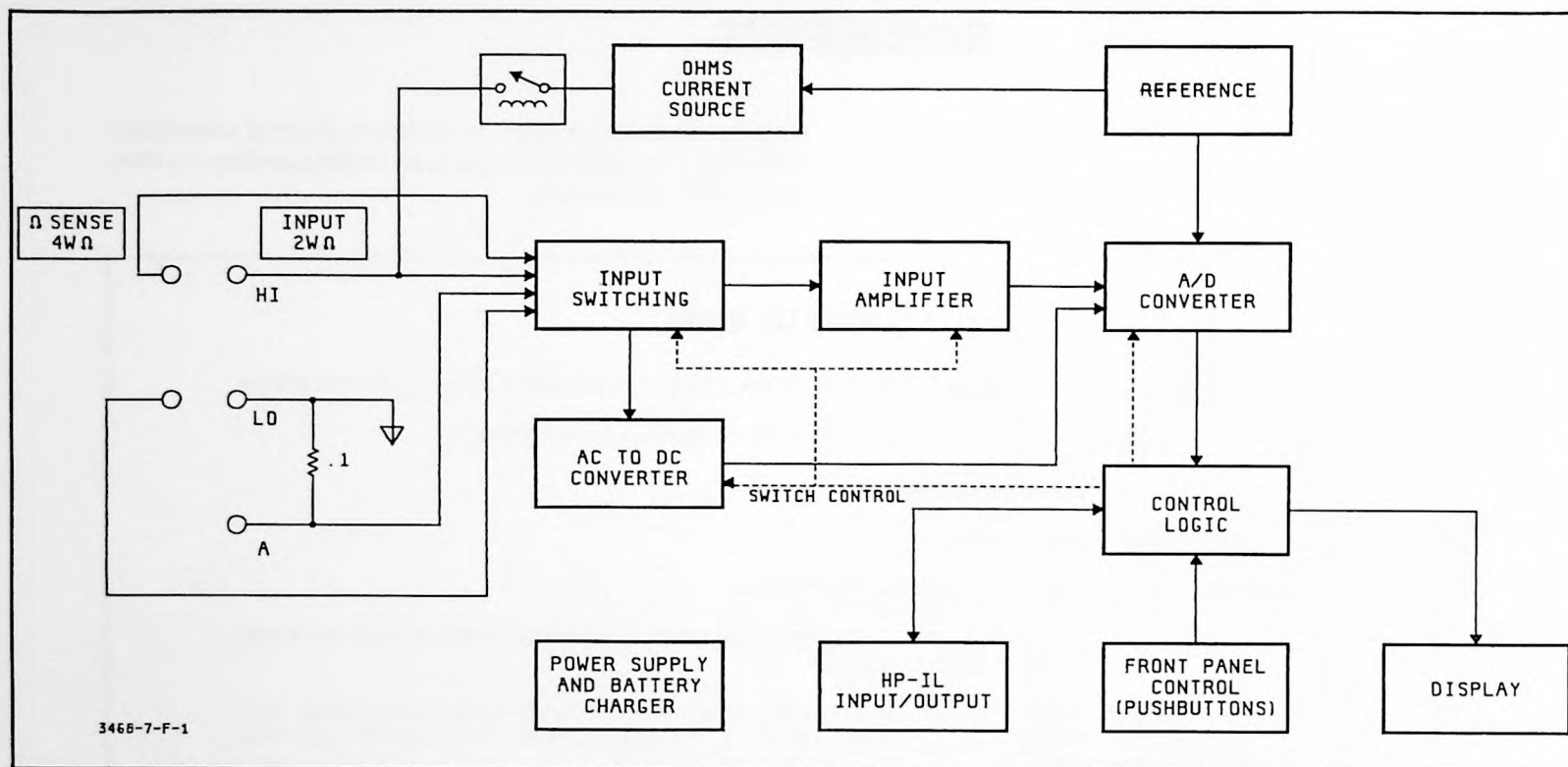
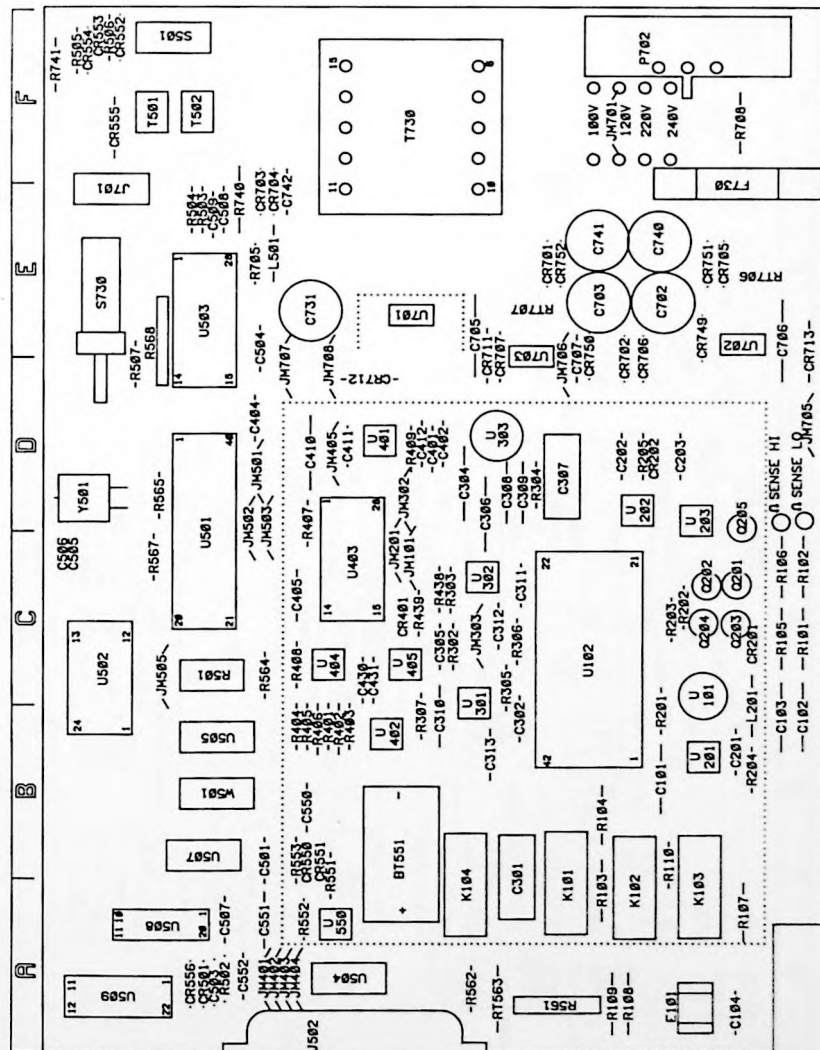


Figure 7-G-2. 3468A/B Block Diagram

COMPONENT LOCATOR  
HP Part Number 03468-66501 Rev A, B, and C  
Applies to 3468A Serial Numbers below 2137A03600

Component	Col	Component	Col	Component	Col
BT551	A, B	CR713	D, E	R403	B
C101	B	CR749	E	R404	B
C102	B, C	CR750	D, E	R405	B
C103	B, C	CR751	E	R406	C, D
C104	A	CR752	E	R407	C, D
C201	B	E101	A	R408	D
C202	D			R409	C
C203	D			R438	C
C301	A, B	F730	E, F	R439	C
C302	B	J502	A	R501	C
C303	D	J701	E, F	R502	E, F
C304	D			R503	E, F
C305	C	JM101	C	R504	D, E
C306	D	JM201	C	R507	A, B
C307	D	JM302	D	R551	A
C308	D	JM303	C	R552	B
C309	D	JM401	A	R553	A
C310	B, C	JM402	A	R561	A
C311	C	JM403	A	R562	A
C312	C	JM404	A	R564	C
C313	B	JM405	D	R565	D
C401	D	JM501	D	R567	D, E
C402	D	JM502	C, D	R705	E
C403	D	JM503	C, D	R708	F
C404	D	JM505	F	R740	E, F
C405	D	JM701	F	R741	F
C410	D	JM705	D	RT563	A
C411	D	JM706	D, E	RT706	E
C430	C	JM707	D, E	RT707	E
C431	C	JM708	D, E	S501	F
C501	B	K101	A, B	S730	D, E
C503	A	K102	A, B	T501	F
C504	D, E	K103	A, B	T502	F
C505	C	K104	A, B	T730	F
C506	C	L201	B, C	U101	B, C
C507	E, F	L501	E	U102	B, C
C508	E, F	P702	F	U201	B
C509	E, F	Q201	C	U202	B
C550	B	Q202	C	U301	C, D
C551	A	Q203	C	U302	B, C
C552	A	Q204	C	U303	C
C553	A	Q205	D	U401	D
C702	E	R101	C	U402	B
C703	E	R102	C	U403	C, D
C705	E	R103	A, B	U404	C
C706	E	R104	C	U405	C
C707	D, E	R105	C	U501	C, D
C731	E	R106	C	U502	B, C
C740	E	R107	A	U503	D, E
C741	E, F	R108	A	U504	A
C742	E, F	R109	A	U505	B
CR201	B	R110	A, B	U507	B
CR202	D	R111	A, B	U508	B
CR401	C	R112	B, C	U509	A
CR501	A	R201	C	U550	E
CR550	A, B	R202	C	U701	E
CR551	F	R203	C	U702	D, E
CR552	F	R204	C	U703	D, E
CR553	F	R205	D	W501	B
CR554	F	R206	E	Y501	D
CR555	A	R207	E		
CR556	A	R208	E		
CR701	D, E	R301	C		
CR702	E	R302	C		
CR703	E, F	R303	C		
CR704	E, F	R304	C		
CR705	E	R305	C		
CR706	E	R306	C		
CR707	D, E	R307	B, C		
CR711	D, E	R401	B		
CR712	D	R402	B		



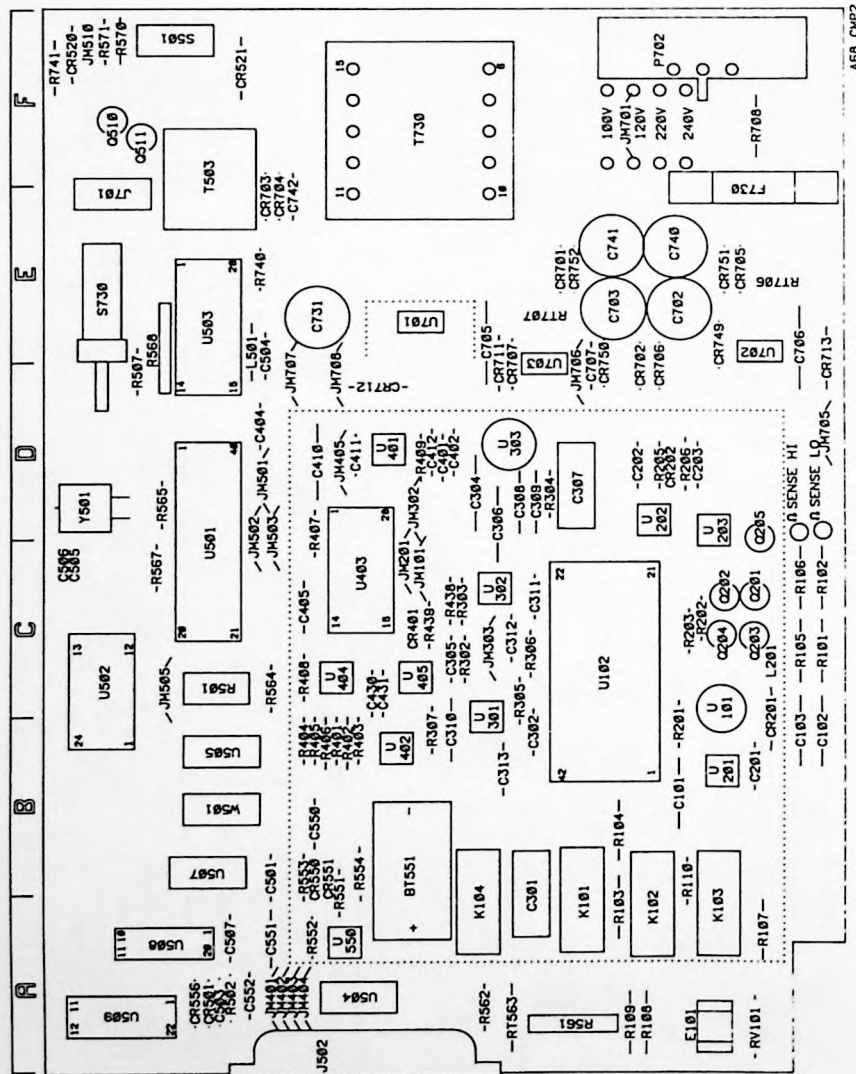
3468-1C

Fig.7-G-3  
Component Locator for 03468-66501 Rev.A,B & C Applies  
to 3468A Serial Numbers below 2137A03600.



**COMPONENT LOCATOR**  
 HP Part Number 03468-66510 Rev A & B  
 Applies to 3468A Serial Numbers 2137A03601 to 2137A13089  
 3468B Serial Numbers Below 2231A02931

Component	Col	Component	Col	Component	Col
BT551	A, B	E101	A	R406	B
C101	B	F730	E, F	R407	C, D
C102	B, C	J502	A	R408	C
C103	B, C	J701	E, F	R409	D
C201	B	JM101	C	R438	C
C202	D	JM201	C	R439	C
C203	D	JM302	D	R501	C
C301	A, B	JM303	C	R502	A
C302	B	JM401	A	R507	D, E
C304	D	JM402	A	R551	A, B
C305	C	JM403	A	R552	A
C306	D	JM404	A	R553	B
C307	D	JM501	D	R554	B
C308	D	JM502	C, D	R555	A
C309	D	JM503	C, D	R562	A
C310	B, C	JM504	D	R564	C
C311	C	JM505	C	R565	D
C312	C	JM510	F	R567	C
C313	B	JM701	D	R568	D, E
C401	D	JM705	D	R570	F
C402	D	JM706	D, E	R571	F
C404	D	JM707	D, E	R708	F
C405	C	JM708	D, E	R741	F
C410	D	K101	A, B	RT563	A
C411	D	K102	A, B	RT706	E
C412	D	K103	A, B	RT707	E
C430	C	K104	A, B	RV101	A
C501	B	L201	B, C	S501	F
C503	A, D, E	L501	D, E	S730	D, E
C504	D, E	P702	F	T503	E, F
C505	C	Q201	C	T730	F
C506	C	Q202	C	U101	B, C
C550	B	Q203	C	U102	B, C
C551	A	Q204	C	U201	B
C552	A	Q205	D	U202	D
C702	E	Q511	F	U203	C, D
C703	E	R101	C	U301	B, C
C705	E	R102	C	U302	C
C706	E	R103	A, B	U401	D
C707	D, E	R104	B	U402	B
C731	E	R105	C	U403	C, D
C740	E	R106	C	U404	C
C741	E, F	R107	A	U405	C
C742	E, F	R108	A	U501	C, D
CR201	B	R109	A	U502	B, C
CR202	D	R110	A, B	U503	D, E
CR401	C	R201	C	U504	A
CR501	F	R202	C	U505	B
CR520	F	R203	C	U507	B
CR521	F	R204	C	U508	A
CR550	A, B	R205	D	U509	A
CR551	A, B	R206	D	U550	A
CR556	A	R207	C	U701	E
CR701	E	R208	C	U702	D, E
CR702	D, E	R303	C	U703	D, E
CR703	E, F	R304	D	W501	B
CR704	E, F	R305	B, C	Y501	D
CR705	E	R306	C		
CR706	D, E	R401	B		
CR707	D, E	R402	B		
CR711	D, E	R403	B		
CR712	D	R404	B		
CR713	D, E	R405	B		
CR749	E				
CR750	D, E				
CR751	D, E				
CR752	E				



**Fig. 7-G-4**  
 Component Locator for 03468-66510, Rev. A & B Applies to  
 3468A Serial Numbers 2137A03601 to 2137A13089, 3468B  
 Serial Numbers Below 2231A02931

COMPONENT LOCATOR  
HP Part Number 03468-66510 Rev C

Applies to 3468A Serial Numbers above 2137A13089  
3468B Serial Numbers above 2213A02930

Component	Col	Component	Col	Component	Col
BT551	A, B	CR750	D, E	R404	B
C101	B	CR751	E	R405	B
C102	B, C	CR752	E	R406	B
C103	B, C			R407	C, D
C109	A	E101	A	R408	C
C201	B	F730	E, F	R409	D
C202	D			R438	C
C203	D	J502	A	R439	C
C204	C, D	J701	E, F	R501	C
C205	D			R502	A
C301	A, B	JM101	C	R507	D, E
C302	A	JM201	C	R551	A, B
C304	D	JM302	D	R554	B
C305	C	JM303	C	R552	A
C306	D	JM401	A	R553	B
C307	D	JM402	A	R561	A
C308	D	JM403	A	R562	A
C309	D	JM404	A	R564	C
C310	B, C	JM405	D	R565	C
C311	C	JM501	D	R567	C
C312	C	JM502	C, D	R568	D, E
C313	B	JM503	C, D	R570	F
C401	D	JM505	C	R571	F
C402	D	JM510	F	R708	E
C404	D	JM701	F	R740	E
C405	C	JM705	D	R741	F
C411	D	JM706	D, E	RT563	A
C412	D	JM707	D, E	RT706	E
C430	C	JM708	D, E	RT707	E
C431	C	K101	A, B	RV101	A
C501	B	K102	A, B	S501	F
C503	A	K103	A, B	S730	D, E
C504	D, E	K104	A, B	T503	E, F
C505	C	L201	B, C	T730	F
C506	C	L501	D, E	U101	B, C
C507	A	P702	F	U102	B, C
C550	B	Q201	C	U201	B
C551	A	Q202	C	U202	D
C552	A	Q203	C	U203	C, D
C702	E	Q204	C	U301	B, C
C703	E	Q205	D	U302	C
C705	E	Q510	F	U303	D
C706	E	Q511	F	U401	D
C707	D, E	R101	C	U402	B
C731	E	R102	C	U403	C, D
C740	E	R103	A, B	U404	C
C741	E	R104	B	U405	C
C742	E, F	R105	C	U501	C, D
CR201	D	R106	C	U502	B, C
CR202	D	R107	A	U503	D, E
CR401	C	R109	A	U504	A
CR501	A	R110	A, B	U505	B
CR520	F	R201	B, C	U507	B
CR521	F	R202	C	U508	A
CR550	A, B	R203	C	U509	A
CR551	A, B	R204	C	U550	A
CR556	A	R205	D	U701	E
CR701	E	R206	D	U702	D, E
CR702	D, E	R302	C	U703	D, E
CR703	E, F	R303	C	W501	B
CR704	E, F	R304	D	Y501	D
CR705	E	R305	D		
CR706	D, E	R306	C		
CR707	D, E	R307	B, C		
CR711	D, E	R401	B		
CR712	D	R402	B		
CR713	D, E	R403	B		
CR749	E				

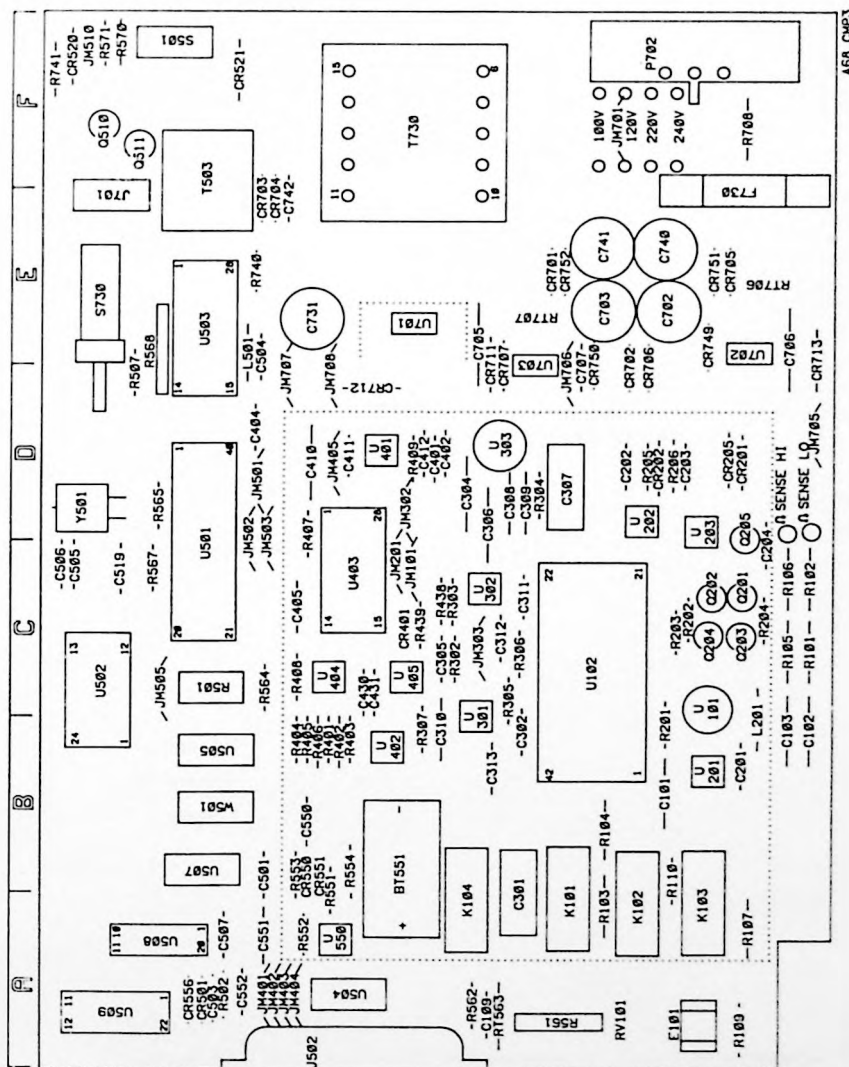


Fig. 7-G-5  
Component Locator for 03468-66510, Rev. C.(ERC 2623 and  
Greater) Applies to 3468A Serial Numbers Above  
2137A13089 3468B Serial Numbers Above 2213A0230

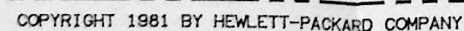


Figure 7-G-6. Input Circuitry and Ohms Current Source  
7-G-7/7-G-8









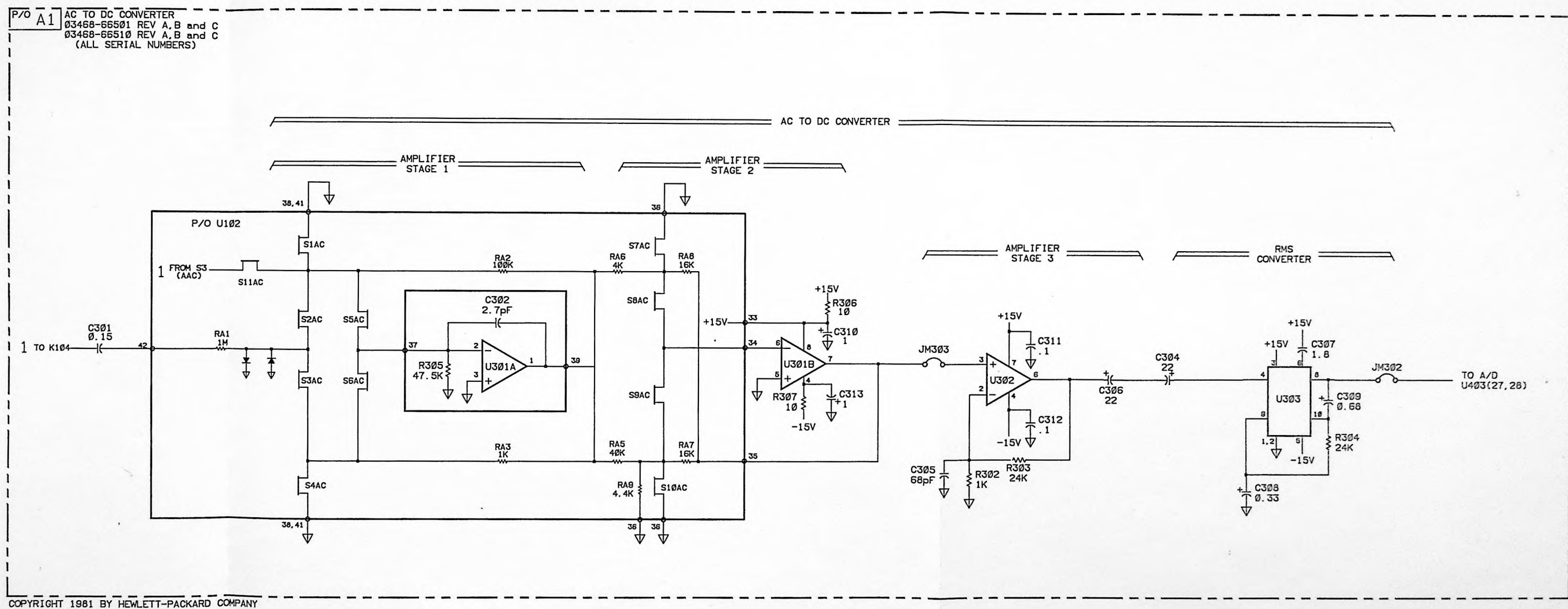
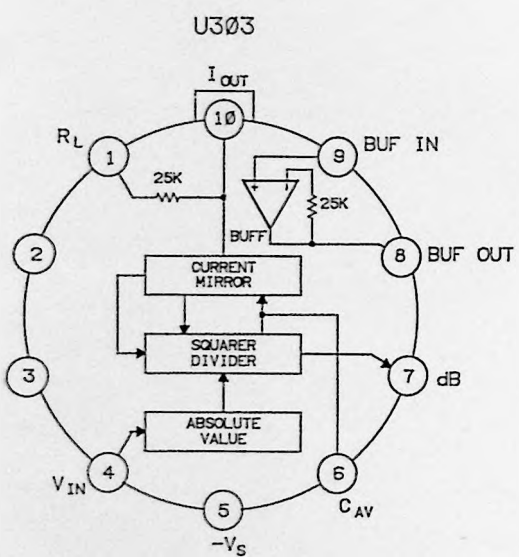
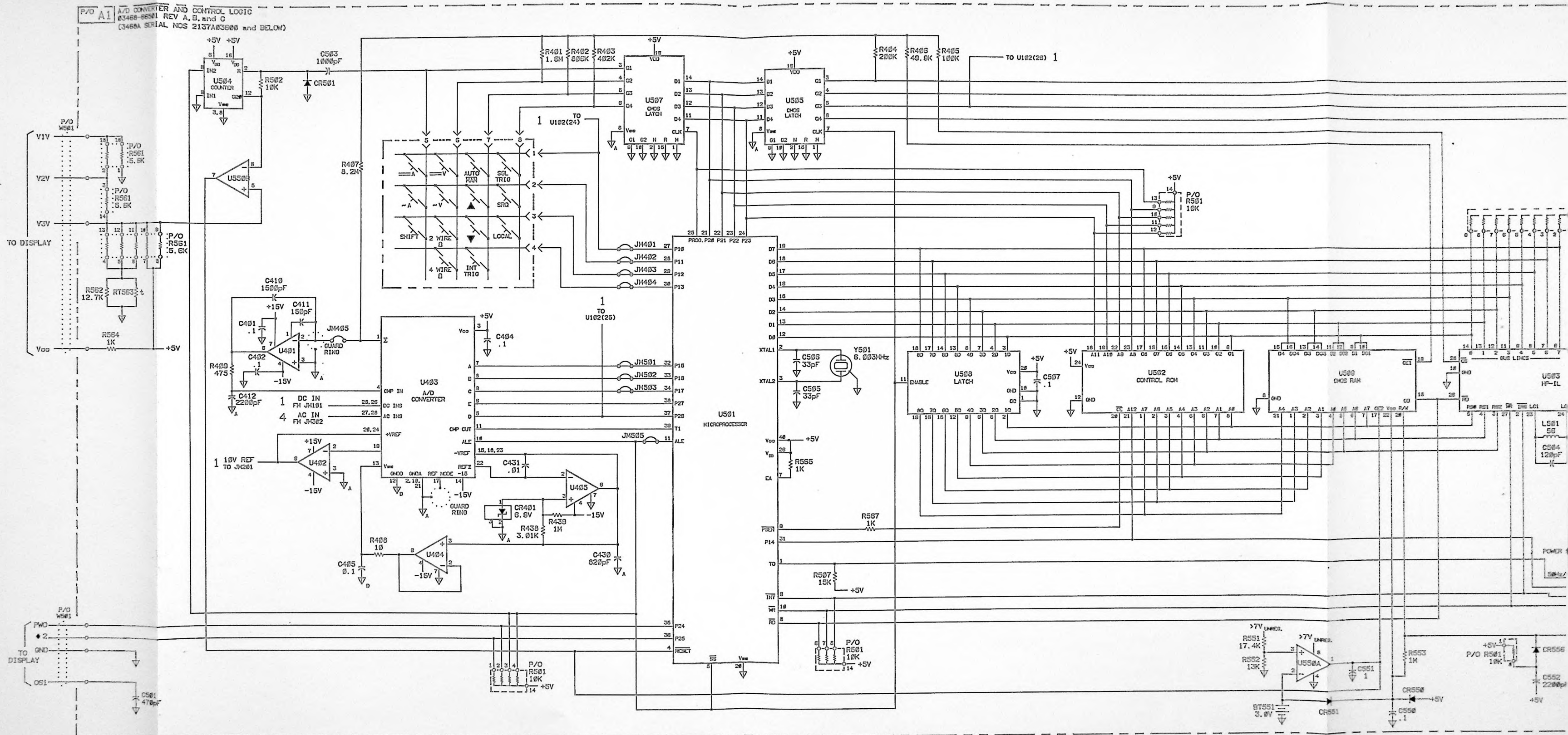


Figure 7-G-9. AC to DC Converter  
7-G-13/7-G-14





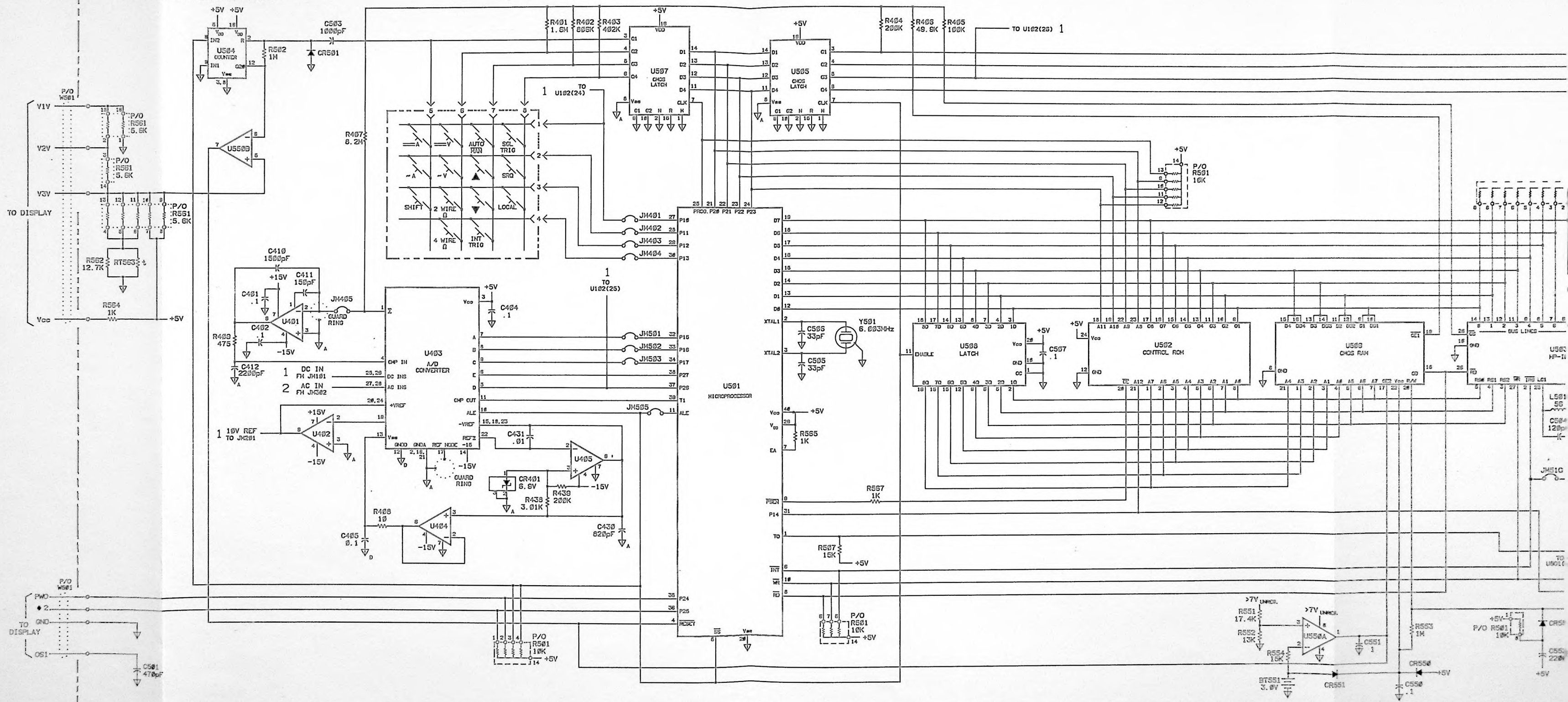
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P/O A1  
A/D CONVERTER AND CONTROL LOGIC 83468-66510 REV A and B  
(3468A SERIAL NOS 2137A03001 to 2137A13090)  
(3468B SERIAL NOS BELOW 2213A02031)



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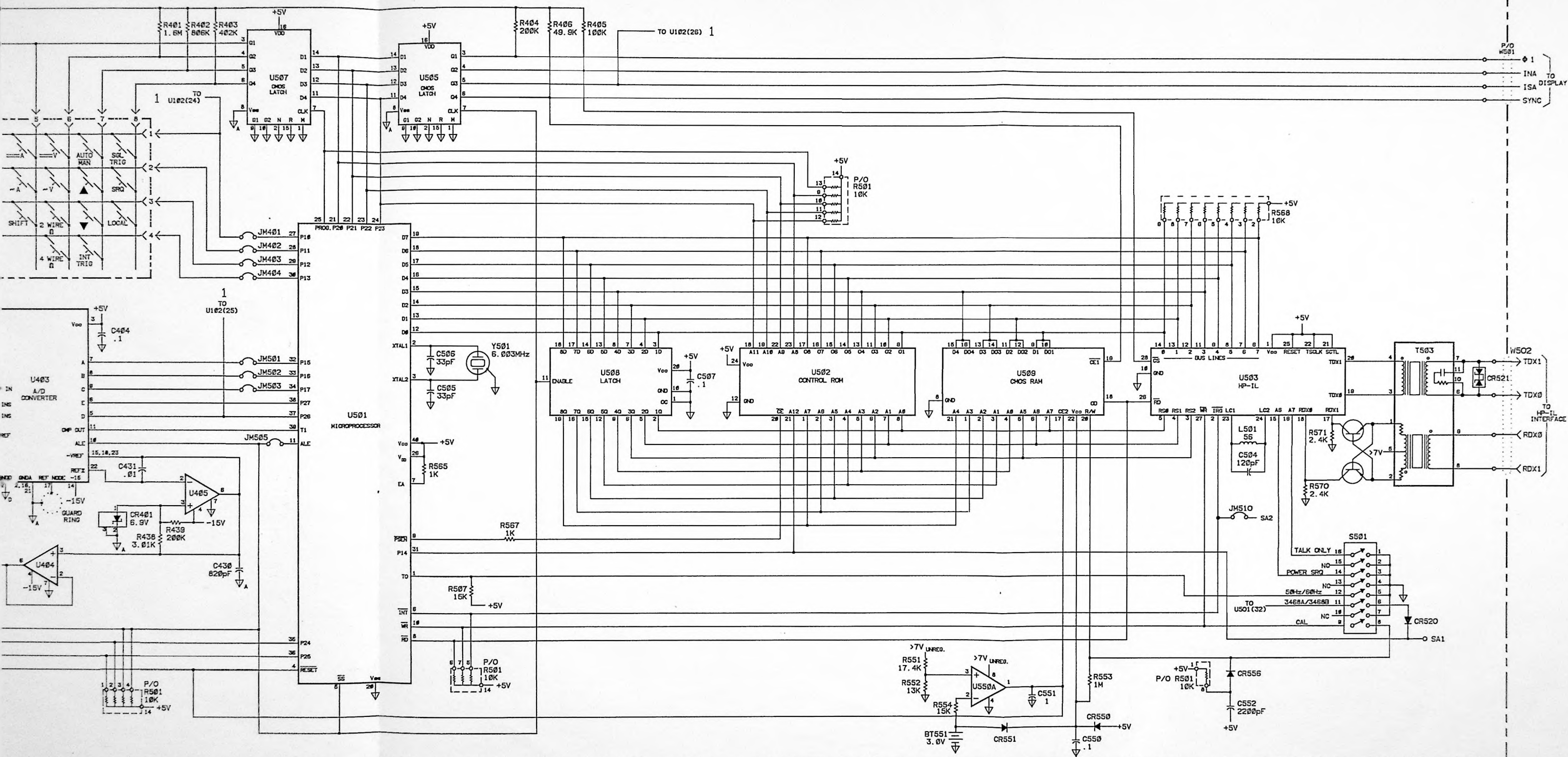
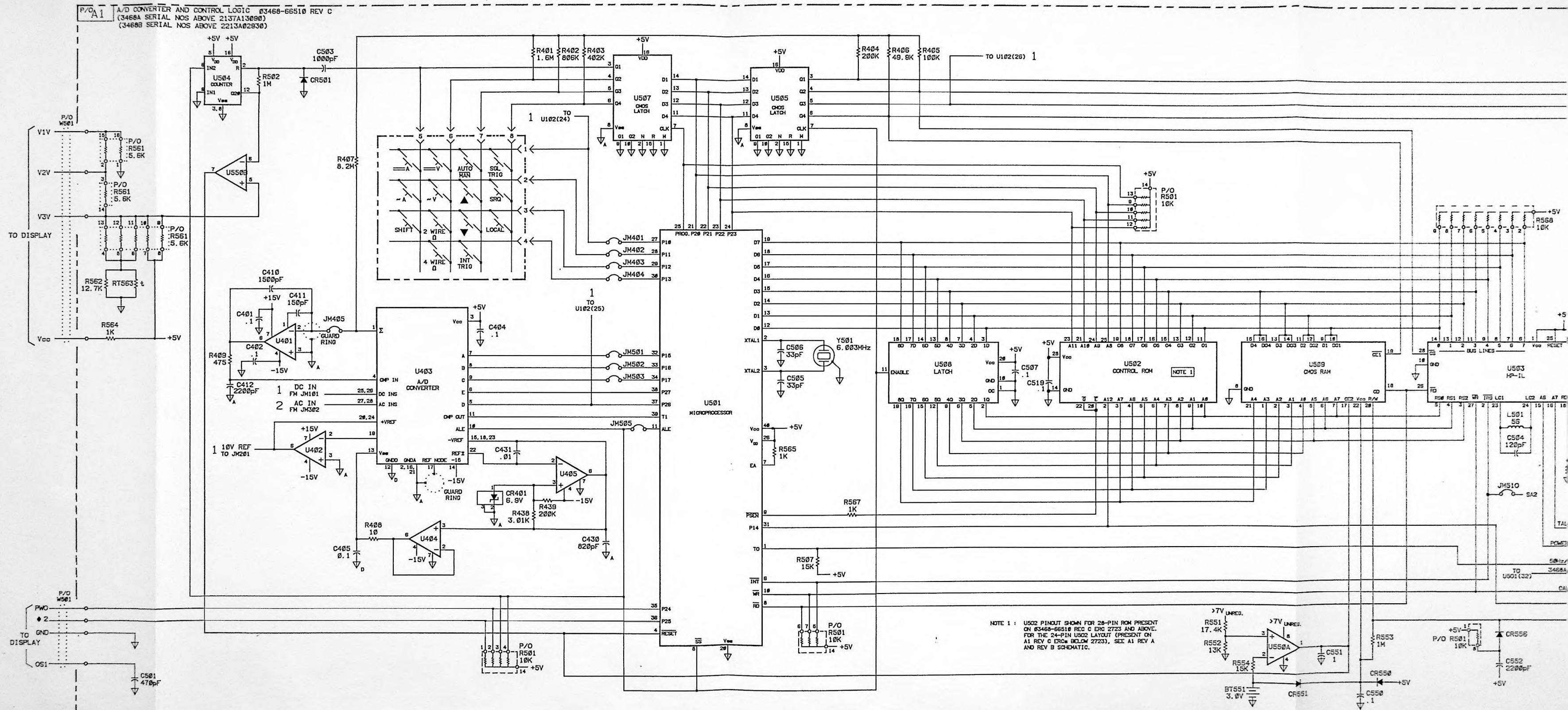


Figure 7-G-11. A/D Converter and Control Logic  
7-G-17/7-G-18





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Figure 7-C



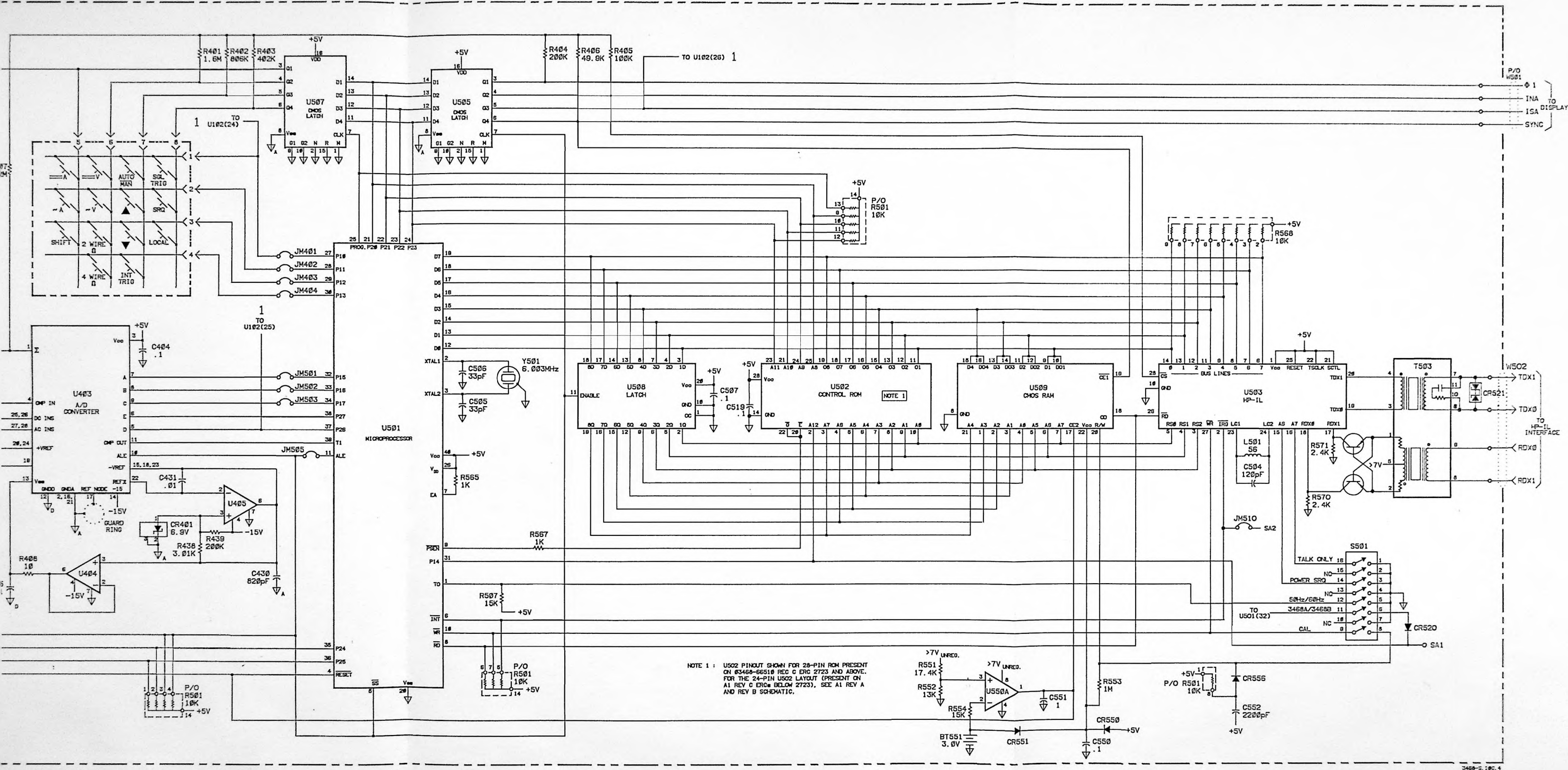
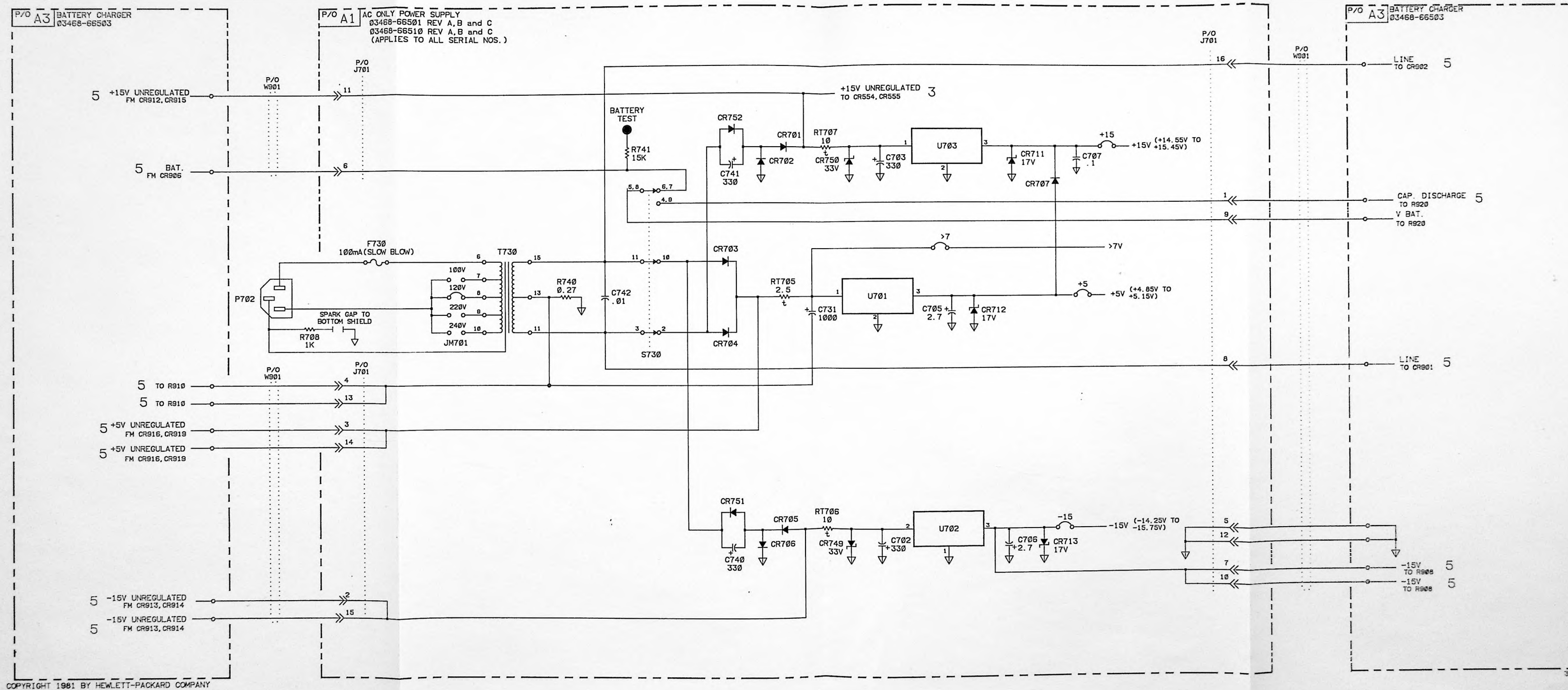


Figure 7-G-12. A/D Converter and Control Logic  
7-G-19/7-G-20





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Figure 7-G-13. Power Supply  
7-G-21/1

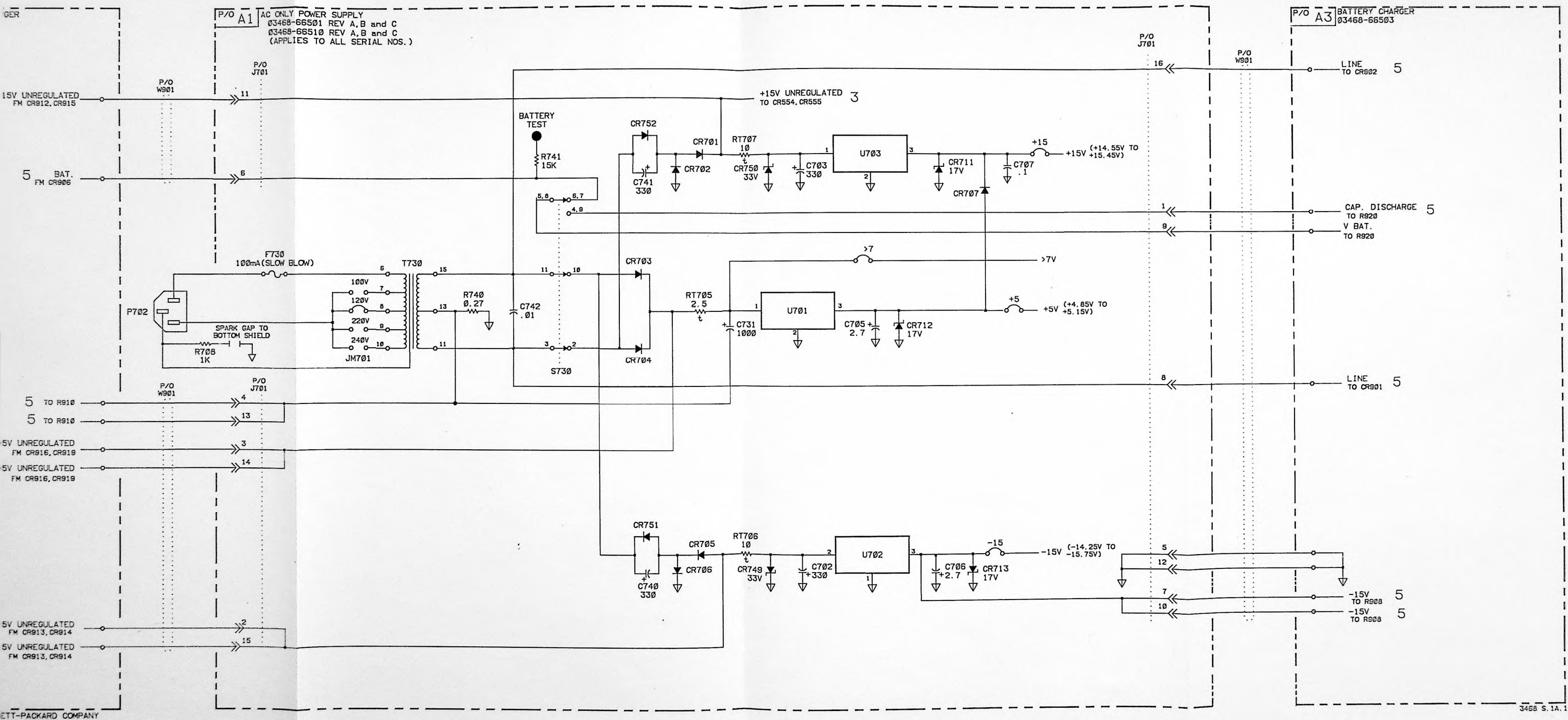
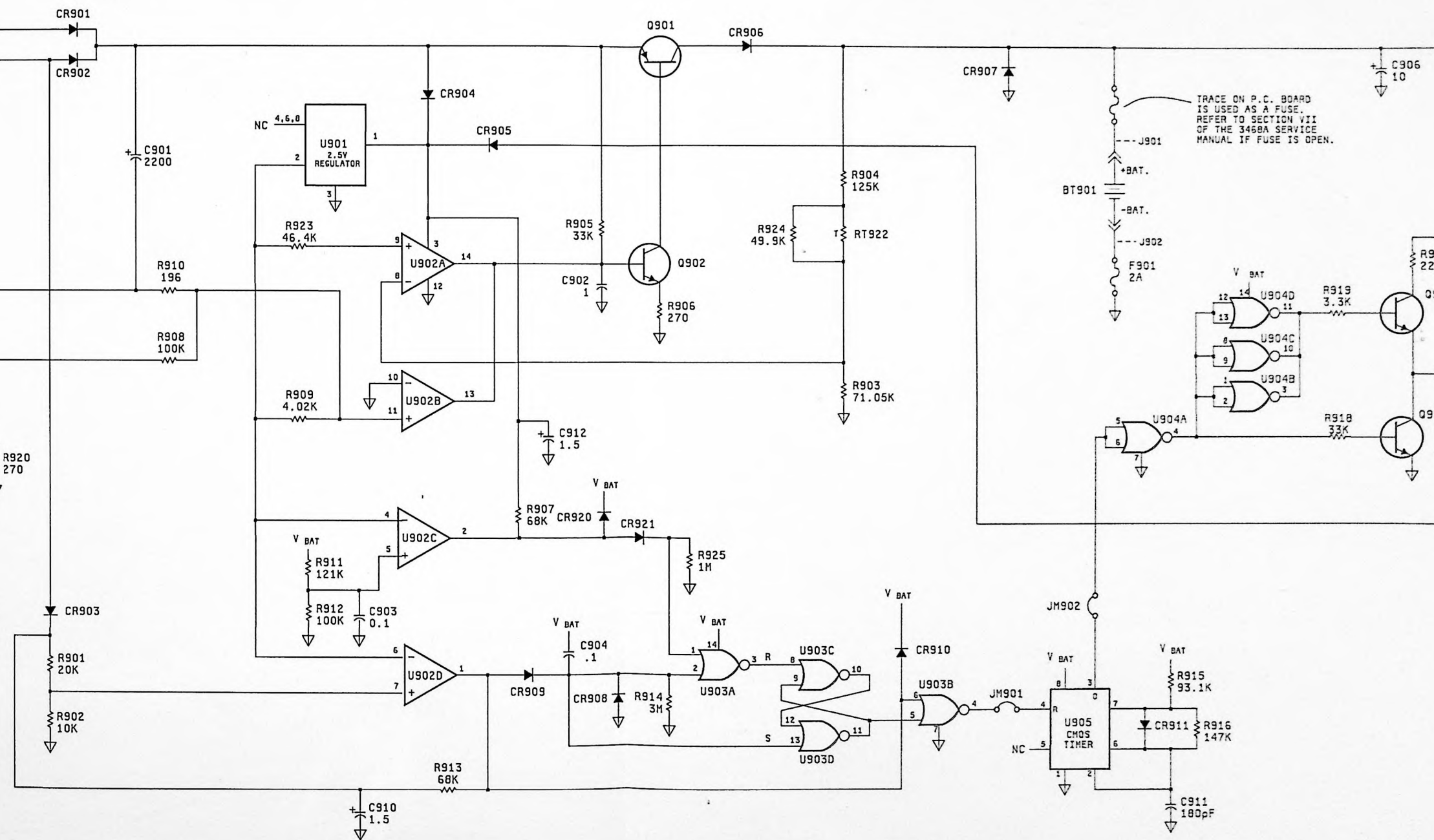
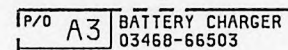
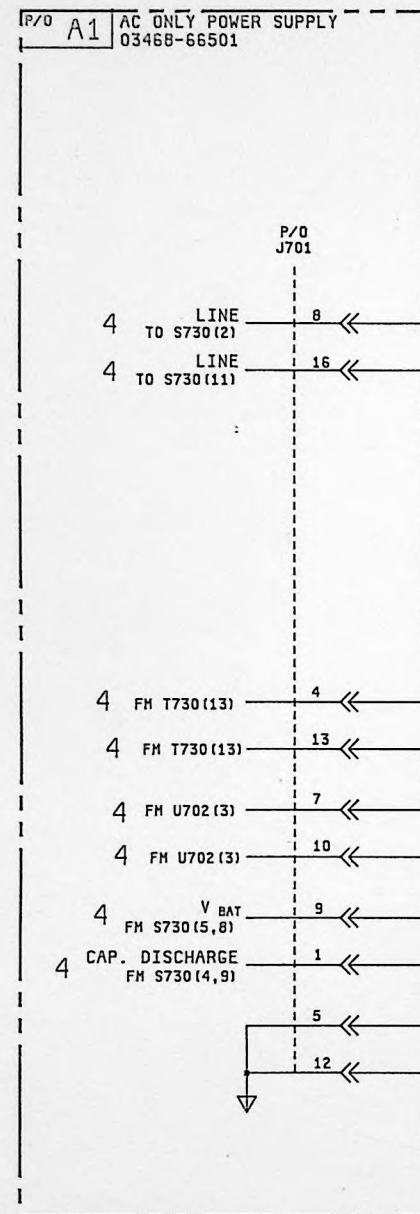


Figure 7-G-13. Power Supplies  
 7-G-21/7-G-22





NOTE

THE SHIELD OF THE BATTERY CHARGER IS CONNECTED TO GROUND.



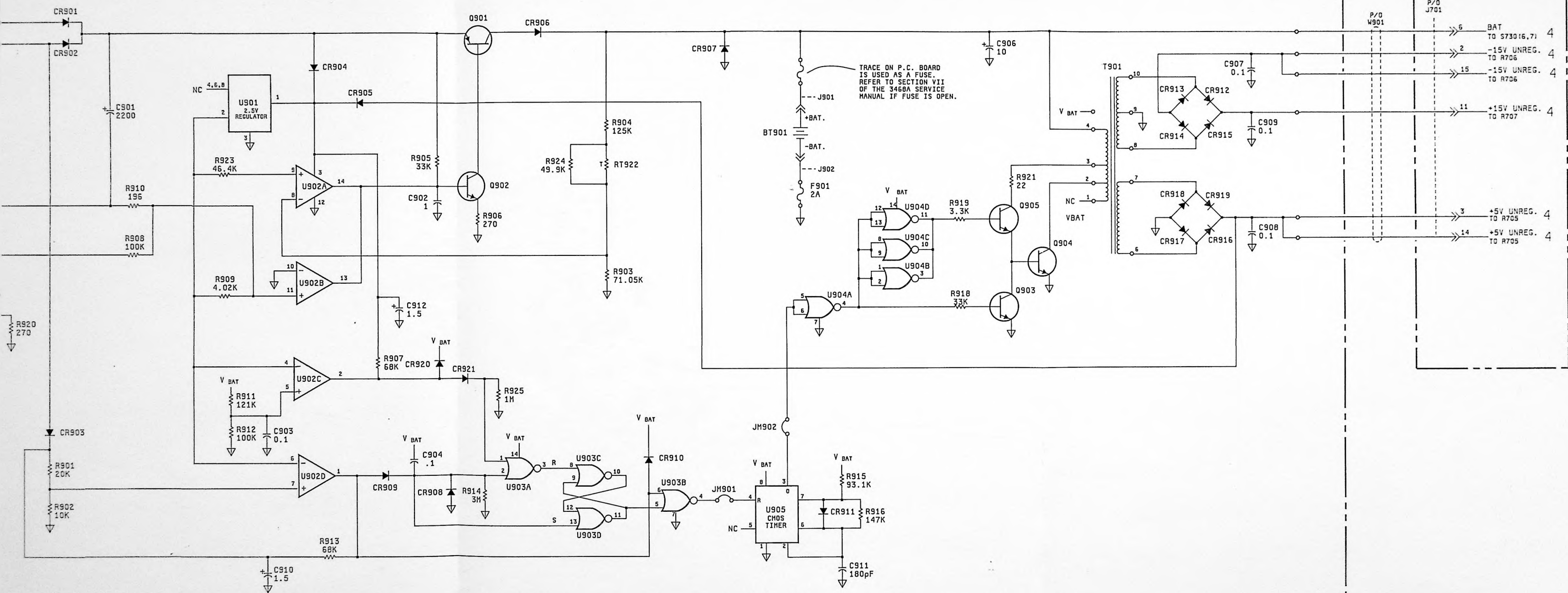
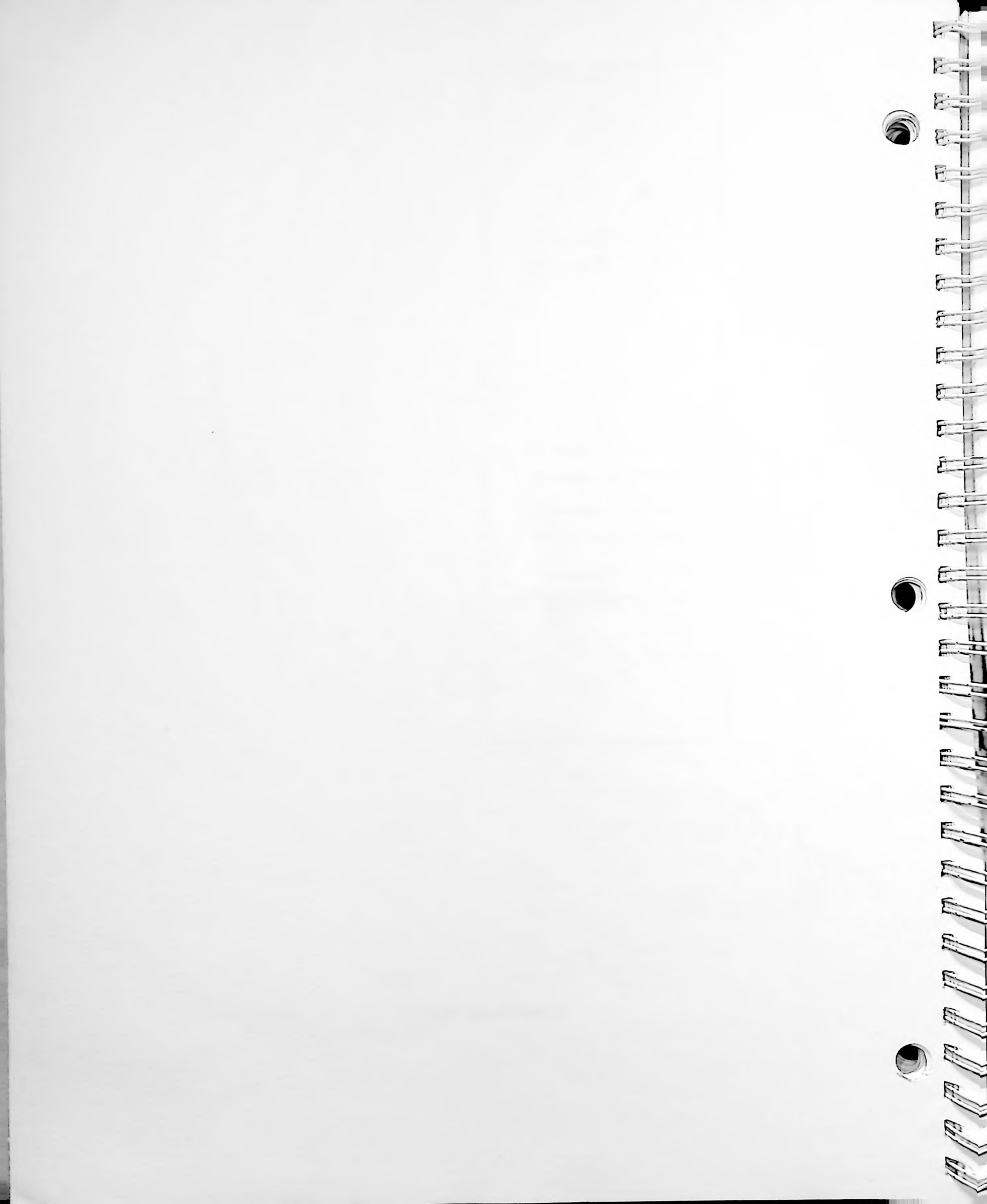


Figure 7-G-14. Battery Charger (Option 001)  
7-G-23/7-G-24



## Appendix A

### A-1. Introduction

A-2. Hewlett-Packard Interface Loop (HP-IL) is a two wire interface that permits communication from one device or instrument to another. As the name implies, devices are connected in a serial loop structure. Data or information, in the form of digital messages, travels from one device to the next around the loop. The following discussion is controller independent but, where appropriate, is dependent on the 3468A/B.

### A-3. General HP-IL Description

A-4. The interface loop consists of a calculator/controller and up to 30 peripheral devices such as the 3468A/B, printer/plotters, etc. Maximum cable length from one device to the next should not exceed 10 meters to maintain noise immunity. Information is transferred from one device to the next around the loop. If the information is not intended for a particular device (see paragraph on addressing), the device merely passes the information on to the next device in the loop. When the information reaches the intended device, the device responds as directed by the information. In this way, the calculator/controller can send information to and receive information from selected devices in the loop according to the devices capabilities.

### A-5. Functional Overview

A-6. Each device in the loop may possess one or more of the three basic device capabilities: Controller, Talker, or Listener. The controller, as the name implies, has the responsibility to control loop activity. The -hp- Model 41C/41CV handheld calculator and the -hp- Model 85 desktop computer are examples of devices which can be used as controllers. They must, of course, be equipped with the proper interface module. Controllers transmit all commands to other devices in the loop and have Talker and Listener capabilities. The 3468A/B cannot serve as a controller. Only one device in the loop may serve as a controller.

A-7. Talkers are devices that have the ability to send data or information (but not commands) through the loop. Note that a talker will not actually send its data or information until told to do so by the controller. The 3468A/B has Talker capabilities. When the 3468A/B is talking on the loop its TLK annunciator will turn on. In special situations, one device may be classified as a Talk-only device and sends information to Listen-only devices. Such a system would not have a controller. For example, the 3468A/B can be configured for Talk-only mode and send measurement results to a printer.

A-8. Listeners are devices with the capability to receive information over the loop. When the 3468A/B is "listening", its LSTN annunciator turns on. Listeners must remain inactive until instructed by the controller to receive the information.

### A-9. Addressing

A-10. Each device in the loop is assigned an address by the controller. The assigned address will probably be different than the factory preset address. The 3468A/B, for example, has a preset address of 22. If the 3468A/B is the only device in the loop with the controller, the controller will assign it an address of "1". The address permits the controller to specify or select a particular device in the loop when sending commands. Addresses are assigned to devices sequentially around the loop in the direction of information flow. The first device after the controller is assigned an address of "1". The second device is assigned the address "2", and so on around the loop.

### A-11. HP-IL System Terms

A-12. The following paragraphs define the terms and concepts used to describe HP-IL system operations.

a. **Address:** Each device in the loop is assigned an address by the controller. The address is used to specify which device in the loop will receive information or send information.

b. **Byte:** A byte is a unit of information consisting of 8 binary digits called bits.

c. **Device:** Any instrument or unit that is HP-IL compatible is called a device.

d. **Device Dependent:** An action a device performs in response to information sent through the loop. The action is characteristic of a particular instrument and will probably vary from device to device.

e. **Frame:** Messages are sent through the loop as a sequence of eleven bits called a message "frame".

f. **Polling:** Polling is a process typically used by a controller to locate a device that has requested service from the controller. There are two types of polling, Serial Poll and Parallel Poll:

1. **Serial Poll.** When the controller executes a serial poll, the addressed device sends one byte of operational information called a status byte. If



more than one device in the loop is capable of requesting service, each device in the loop must be serial polled until the device that requested service is located.

2. **Parallel Poll.** This method obtains a status bit from eight devices in the loop. The 3468A/B does not respond to a parallel poll.

### A-13. Messages

A-14. Every message sent through the loop is sent as a sequence of eleven bits called a message frame. Commands, such as Listen, are made up of one or more message frames. The first bit in each message frame is a sync bit and is specially coded so that each device can recognize the beginning of a frame. The sync bit and the two following bits are called control bits and are used to determine the classification of the message frame. There are three major classifications of frames: Command, Ready, and Data. The remaining eight bits are the data bits and specify the particular message within the classification.

A-15. Normally only one message is in transit around the loop at any given time. In general, when a device sources a message it waits until the message goes completely around the loop and returns before transmitting the next message. This is part of a process called loop handshaking and guarantees that talkers and controllers do not send messages faster than other devices can accept them. It also provides an excellent error-checking capability. Each message must pass through each device. When a device receives a message, it does not pass it on to the

next device until it is ready to receive the next message. Consequently, when the message returns to the sourcing device, it knows for certain that all devices in the loop have received the message and are ready for the next.

### A-16. 3468A/B Loop Capabilities

A-17. The following table lists the HP-IL functional subsets that the 3468A/B responds to and uses.

R	The 3468A handshakes as a receiver
D	Handshakes as a driver to the next device
AH	Handshakes as an acceptor
SH1	Handshakes as a source
T1,2,- 3,5,6	Basic Talker, Send Status, Send Device ID, Talk Only, and unaddressed as a Talker when addressed to Listen
TEO	No extended Talker capability
L1,3	Basic Listener and unaddressed to Listen when addressed to Talk
LEO	No extended Listener capability
CO	The 3468A cannot serve as a controller
AA1	Can be autoaddressed by the controller
AE0	No extended addressing capability
AM0	No multiple addressing capability
DC2	The 3468A responds to a Device Clear and Selected Device Clear
DT1	The 3468A responds to a Device Trigger
RL2	Basic Remote, Local, and Local Lockout capability
SR2	Basic Service Request and Asynchronous Service Request capability
PPO	The 3468A does not respond to a parallel Poll
MS1	The 3468A does have a manual Service Request
PDO	The 3468A does not have a power-down capability
DD0	The 3468A does not implement device dependent Talker or Listener commands

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SANTIAGO

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Telex: 340192 ASC CK

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Metrolab S.A.

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Telex: 340892 OLYMP

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86000 **POITIERS**  
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Rue Louis Kerautrel-Botmel  
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59658 VILLENEUVE D'ASCQ Cedex  
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Telex: 31146 BERSAL SB  
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**JERUSALEM** 94467  
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11 Masad Street  
67060

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Tel: (02) 923691  
Telex: 334632

A,C,CM,E,M,P  
Hewlett-Packard Italiana S.p.A.  
Via Nuova Rivoltana 95  
20090 **LIMITO** (Milano)  
Tel: (02) 92761

Hewlett-Packard Italiana S.p.A.  
Via Nuova San Rocco a  
Capodimonte, 62/A  
I-80131 **NAPOLI**

Tel: (081) 7413544  
Telex: 710698

A\*\*,C,E,M  
Hewlett-Packard Italiana S.p.A.  
Via Orazio 16  
80122 **NAPOLI**  
Tel: (081) 7611444

Hewlett-Packard Italiana S.p.A.  
Via Pellizzo 15  
35128 **PADOVA**  
Tel: (049) 8070166

Telex: 430315  
A,C,E,M  
Hewlett-Packard Italiana S.p.A.  
Viale C. Pavese 340  
I-00144 **ROMA EUR**

Tel: (06) 54831  
Telex: 610514  
A,C,E,M,P\*

Hewlett-Packard Italiana S.p.A.  
Via di Casellina 57/C  
I-50018 **SCANDICCI-FIRENZE**  
Tel: (055) 753863

C,E,M  
Hewlett-Packard Italiana S.p.A.  
Corso Svizzera, 185  
I-10144 **TORINO**  
Tel: (011) 74 4044  
Telex: 221079  
A\*,C,E

## IVORY COAST

S.I.T.E.L.  
Societe Ivoirienne de  
Telecommunications  
Bd. Giscard d'Estaing  
Carrefour Marcory  
Zone 4.A.  
Boite postale 2580  
**ABIDJAN 01**  
Tel: 353600  
Telex: 43175  
E

S.I.T.I.  
Immeuble "Le General"  
Av. du General de Gaulle  
01 BP 161  
**ABIDJAN 01**  
Tel: 321227  
C,P

## JAPAN

Yokogawa-Hewlett-Packard Ltd.  
152-1, Onna  
**ATSUGI**, Kanagawa, 243  
Tel: (0462) 25-0031  
C,CM,E

Yokogawa-Hewlett-Packard Ltd.  
Meiji-Seimei Chiba Bldg.  
3-1 Hon Chiba-Cho  
**CHIBA**, 280  
Tel: (0472) 25 7701  
C,E

Yokogawa-Hewlett-Packard Ltd.  
Yasuda-Seimei Hiroshima Bldg.  
6-11, Hon-dori, Naka-ku  
**HIROSHIMA**, 730  
Tel: (082) 241-0611

Yokogawa-Hewlett-Packard Ltd.  
Towa Building  
2-3, Kaigan-dori, 2 Chome Chuo-ku  
**KOBE**, 650  
Tel: (078) 392-4791  
C,E

Yokogawa-Hewlett-Packard Ltd.  
Kumagaya Asahi 82 Bldg.  
3-4 Tsukuba  
**KUMAGAYA**, Saltama 360  
Tel: (0485) 24-6563  
C,CM,E

Yokogawa-Hewlett-Packard Ltd.  
Asahi Shinbun Daiichi Seimei Bldg.  
4-7, Hanabata-cho  
**KUMAMOTO**, 860  
Tel: (0963) 54-7311  
C,E

Yokogawa-Hewlett-Packard Ltd.  
Shin-Kyoto Center Bldg.  
614, Higashi-Shiokoji-cho  
Karasuma-Nishiru  
Shiokoji-dori, Shlmogyo-ku  
**KYOTO**, 600  
Tel: 075-343-0921  
C,E

Yokogawa-Hewlett-Packard Ltd.  
Mito Mitsui Bldg.  
4-73, Sanno-maru, 1 Chome  
**MITO**, Ibaraki 310  
Tel: (0292) 25-7470  
C,CM,E



# SALES & SUPPORT OFFICES

Arranged alphabetically by country

## JAPAN (Cont'd)

Yokogawa-Hewlett-Packard Ltd.  
Meiji-Seimei Kokubun Bldg.

7-8 Kokubun, 1 Chome, Sendai  
**MIYAGI, 980**

Tel: (0222) 25-1011  
C,E

Yokogawa-Hewlett-Packard Ltd.  
Gohda Bldg. 2F

2-10 Gohda 1 Chome  
Okaya-Shi

**NAGANO, 394**

Tel: (0266) 23 0851  
C,E

Yokogawa-Hewlett-Packard Ltd.  
Nagoya Kokusai Center Building

47-1, Nagono, 1 Chome  
Nakamura-ku

**NAGOYA, 450**

Tel: (052) 571-5171  
C,CM,E,M

Yokogawa-Hewlett-Packard Ltd.  
Sai-Kyo-Ren Building

1-2 Dote-cho

**OHMIYA OHMIYA, Saitama 330**

Tel: (0486) 45-8031

Yokogawa-Hewlett-Packard Ltd.  
Chuo Bldg.,

4-20 Nishinakajima, 5 Chome

Yodogawa-ku

**OSAKA, 532**

Tel: (06) 304-6021

Telex: YHPOSA 523-3624

C,CM,E,M,P\*

Yokogawa-Hewlett-Packard Ltd.  
27-15, Yabe, 1 Chome

**SAGAMIHARA Kanagawa, 229**

Tel: 0427 59-1311

Yokogawa-Hewlett-Packard Ltd.  
Motoshiro-cho Dai-ich Seimei Bldg. 1F

219-21 Motoshiro-cho,

Hamamatsu-shi

**SHIZUOKA, 430**

Tel: (0534) 56 1771

C,E

Yokogawa-Hewlett-Packard Ltd.  
Dalichi Seimei Bldg.

7-1, Nishi Shinjuku, 2 Chome

Shinjuku-ku, **TOKYO 160**

Tel: 03-348-4611

C,E,M

Yokogawa Hewlett-Packard Ltd.  
9-1, Takakura-cho

Hachioji-shi, **TOKYO, 192**

Tel: 0426-42-1261

C,E

Yokogawa-Hewlett-Packard Ltd.  
29-21 Takaido-Higashi, 3 Chome

Suginami-ku **TOKYO 168**

Tel: (03) 331-6111

Telex: 232-2024 YHPTOK

C,CM,E,P\*

Yokogawa Hokushin Electric  
Corporation

Shinjuku-NS Bldg. 10F

4-1 Nishi-Shinjuku 2-Chome

Shinjuku-ku

**TOKYO, 163**

Tel: (03) 349-1859

Telex: J27584

A

Yokogawa Hokushin Electric Corp.

9-32 Nokacho 2 Chome

2 Chome Musashino-shi

**TOKYO, 180**

Tel: (0422) 54-1111

Telex: 02822-421 YEW MTK J

A

Yokogawa-Hewlett-Packard Ltd.  
Meiji-Seimei

Utsunomiya Oodori Building

1-5 Oodori, 2 Chome

**UTSUNOMIYA, Tochigi 320**

Tel: (0286) 33-1153

C,E

Yokogawa-Hewlett-Packard Ltd.

Yasuda Seimei Nishiguchi Bldg.

30-4 Tsuruya-cho, 3 Chome

Kanagawa-ku, **YOKOHAMA 221**

Tel: (045) 312-1252

C,CM,E

## JORDAN

Scientific and Medical Supplies Co.

P.O. Box 1387

**AMMAN**

Tel: 24907, 39907

Telex: 21456 SABCO JO

C,E,M,P

## KENYA

ADCOM Ltd., Inc., Kenya

P.O.Box 30070

**NAIROBI**

Tel: 331955

Telex: 22639

E,M

## KOREA

Samsung Hewlett-Packard Co. Ltd.

Dongbang Yeoeuldo Building

12-16th Floors

36-1 Yeoeuldo-Dong

Youngdeungpo-Ku

**SEOUL**

Tel: 784-4666, 784-2666

Telex: 25166 SAMSAN K

C,CM,E,M,P

Young In Scientific Co., Ltd.

Youngwha Building

547 Shinsa Dong, Kangnam-Ku

**SEOUL 135**

Tel: 546-7771

Telex: K23457 GINSCO

A

Dongbang Healthcare

Products Co. Ltd.

Suite 301 Medical Supply Center

Bldg. 1-31 Dongsungdong

Jong Ro-gu, **SEOUL**

Tel: 764-1171, 741-1641

Telex: K25706 TKBKO

Cable: TKBEEPKO

M

## KUWAIT

Al-Khaldiya Trading & Contracting

P.O. Box 830

**SAFAT**

Tel: 424910, 411726

Telex: 22481 AREEG KT

Cable: VISCOUNT

E,M,A

Gulf Computing Systems

P.O. Box 25125

**SAFAT**

Tel: 435969

Telex: 23648

P

Photo & Cine Equipment

P.O. Box 270

**SAFAT**

Tel: 2445111

Telex: 22247 MATIN KT

Cable: MATIN KUWAIT

P

W.J. Towell Computer Services

P.O. Box 5897

**SAFAT**

Tel: 2462640/1

Telex: 30336 TOWELL KT

C

## LEBANON

Computer Information Systems S.A.L.

Chammas Building

P.O. Box 11-6274 Dora

**BEIRUT**

Tel: 89 40 73

Telex: 42309

C,E,M,P

## LIBERIA

Unichemicals Inc.

P.O. Box 4509

**MONROVIA**

Tel: 224282

Telex: 4509

E

## MADAGASCAR

Technique et Precision

12, rue de Nice

P.O. Box 1227

101 **ANTANANARIVO**

Tel: 22090

Telex: 22255

P

## LUXEMBOURG

Hewlett-Packard Belgium S.A./N.V.

Blvd de la Woluwe, 100

Woluwedal

B-1200 **BRUSSELS**

Tel: (02) 762-32-00

Telex: 23-494 paloben bru

A,C,CM,E,M,P

## MALAYSIA

Hewlett-Packard Sales (Malaysia)

Sdn. Bhd.

9th Floor

Chung Khlaw Bank Building

46, Jalan Raja Laut

50350 **KUALA LUMPUR**

Tel: 2986555

Telex: 31011 HPSM MA

A,C,E,M,P\*

Protel Engineering

P.O.Box 1917

Lot 6624, Section 64

23/4 Pending Road

Kuching, **SARAWAK**

Tel: 36299

Telex: 70904 PROMAL MA

Cable: PROTELENG

A,E,M

## MALTA

Philip Toledo Ltd.

Birkirkara P.O. Box 11

Notabile Rd.

**MRIEHEL**

Tel: 447 47, 455 66, 4915 25

Telex: Media MW 649

E,M,P

## MAURITIUS

Blanche Birger Co. Ltd.

18, Jules Koenig Street

**PORT LOUIS**

Tel: 20828

Telex: 4296

P

## MEXICO

Hewlett-Packard de Mexico,

S.A. de C.V.

Rio Nio No. 4049 Desp. 12

Fracc. Cordoba

**JUAREZ**

Tel: 161-3-15-62

P

Hewlett-Packard de Mexico,

S.A. de C.V.

Condominio Kadereyta

Circuito del Mezon No. 186 Desp. 6

**COL. DEL PRADO - 76030 Qro.**

Tel: 463-6-02-71

P

Hewlett-Packard de Mexico,

S.A. de C.V.

Monti Morelos No. 299

Fraccionamiento Loma Bonita 45060

**GUADALAJARA, Jalisco**

Tel: 36-31-48-00

Telex: 0684 186 ECOME

P

Microcomputadoras Hewlett-Packard,

S.A.

Monti Pelvoux 115

**LOS LOMAS, Mexico, D.F.**

Tel: 520-9127

P

Microcomputadoras Hewlett-Packard,

S.A. de C.V.

Monte Pelvoux No. 115

Lomas de Chapultepec, 11000

**MEXICO, D.F.**

Tel: 520-9127

P

Hewlett-Packard de Mexico,

S.A. de C.V.

Monte Pelvoux No. 111

Lomas de Chapultepec

11000 **MEXICO, D.F.**

Tel: 5-40-62-28, 72-66, 50-25

Telex: 17-74-507 HEWPACK MEX

A,C,CM,E,M,P

Hewlett-Packard De Mexico (Polanco)

Avenida Ejercito Nacional #579

2da y 3er piso

Colonla Granada 11560

**MEXICO D.F.**

Tel: 254-4433

P



Hewlett-Packard de Mexico,  
S.A. de C.V.  
Czda. del Valle  
409 Ote. 4th Piso  
Colonia del Valle  
Municipio de Garza Garcia Nuevo Leon  
66220 **MONTERREY**, Nuevo León  
Tel: 83-78-42-40  
Telex: 382410 HPMY  
C

Infograficas y Sistemas del Noreste,  
S.A.  
Rio Orinoco #171 Oriente  
Despacho 2001  
Colonia Del Valle  
**MONTERREY**  
Tel: 559-4415, 575-3837  
Telex: 483164  
A,E

Hewlett-Packard de Mexico,  
S.A. de C.V.  
Blvd. Independencia No. 2000 Ote.  
Col. Estrella  
**TORREON, COAH.**  
Tel: 171-18-21-99  
P

#### **MOROCCO**

Etablissement Hubert Dolbeau & Fils  
81 rue Karatchi  
B.P. 11133  
**CASABLANCA**  
Tel: 3041-82, 3068-38  
Telex: 23051, 22822  
E

Gerep  
2, rue Agadir  
Boite Postale 156  
**CASABLANCA 01**  
Tel: 272093, 272095  
Telex: 23 739  
P

Sema-Maroc  
Dept. Seric  
6, rue Lapebie  
**CASABLANCA**  
Tel: 260980  
Telex: 21641  
C,P

#### **NETHERLANDS**

Hewlett-Packard Nederland B.V.  
Startbaan 16  
NL-1187 XR **AMSTELVEEN**  
P.O. Box 667  
NL-1180 AR **AMSTELVEEN**  
Tel: (020) 547-6911  
Telex: 13 216 HEPA NL  
A,C,CM,E,M,P

Hewlett-Packard Nederland B.V.  
Bongerd 2  
NL 2906VK **CAPELLE A/D IJSEL**  
P.O. Box 41  
NL 2900AA **CAPELLE A/D IJSEL**  
Tel: (10) 51-64-44  
Telex: 21261 HEPAC NL  
C,E

Hewlett-Packard Nederland B.V.  
Pastoor Petersstraat 134-136  
NL 5612 LV **EINDHOVEN**  
P.O. Box 2342  
NL 5600 CH **EINDHOVEN**  
Tel: (040) 326911  
Telex: 51484 hepae nl  
C,E,P

#### **NEW ZEALAND**

Hewlett-Packard (N.Z.) Ltd.  
5 Owens Road  
P.O. Box 26-189  
Epsom, **AUCKLAND**  
Tel: 687-159  
Cable: HEWPAK Auckland  
C,CM,E,P\*  
Hewlett-Packard (N.Z.) Ltd.  
184-190 Willis Street  
**WELLINGTON**  
P.O. Box 9443  
Courtenay Place, **WELLINGTON 3**  
Tel: 877-199  
Cable: HEWPACK Wellington  
C,CM,E,P

Northrop Instruments & Systems Ltd.  
369 Khyber Pass Road  
P.O. Box 8602  
**AUCKLAND**  
Tel: 794-091  
Telex: 60605  
A,M

Northrop Instruments & Systems Ltd.  
110 Mandeville St.  
P.O. Box 8388  
**CHRISTCHURCH**  
Tel: 488-873  
Telex: 4203  
A,M

Northrop Instruments & Systems Ltd.  
Sturdee House  
85-87 Ghuznee Street  
P.O. Box 2406  
**WELLINGTON**  
Tel: 850-091  
Telex: NZ 3380  
A,M

#### **NIGERIA**

Elmeco Nigeria Ltd.  
46, Calcutta Crescent Apapa  
P.O. Box 244and  
**LAGOS**  
E

#### **NORTHERN IRELAND** **See United Kingdom**

#### **NORWAY**

Hewlett-Packard Norge A/S  
Folke Bernadottes vei 50  
P.O. Box 3558  
N-5033 FYLLINGSDALEN (Bergen)  
Tel: 0047/5/16 55 40  
Telex: 76621 hpnas n  
C,E,M

Hewlett-Packard Norge A/S  
Osterndalen 16-18  
P.O. Box 34  
N-1345 **OESTERAAS**  
Tel: 0047/2/24 60 90  
Telex: 76621 hpnas n  
A,C,CM,E,M,P

Hewlett-Packard Norge A/S  
Boehmergt. 42  
Box 2470  
N-5037 **SOLHEIMSVIK**  
Tel: 0047/5/29 00 90

#### **OMAN**

Khimjil Ramdas  
P.O. Box 19  
**MUSCAT/SULTANATE OF OMAN**  
Tel: 795 901  
Telex: 3489 BROKER MB MUSCAT  
P

Suhail & Saud Bahwan  
P.O. Box 169  
**MUSCAT/SULTANATE OF OMAN**  
Tel: 734 201-3  
Telex: 5274 BAHWAN MB  
E

Imtac LLC  
P.O. Box 9196  
**MINA AL FAHAL/SULTANATE OF OMAN**  
Tel: 561 695, 5602078, 561010  
Telex: 5298 Tawoos On  
A,C,M

#### **PAKISTAN**

Mushko & Company Ltd.  
House No. 16, Street No. 16  
Sector F-6/3  
**ISLAMABAD**  
Tel: 824545  
Cable: FEMUS Islamabad  
A,E,P\*  
Mushko & Company Ltd.  
Oosman Chambers  
Abdullah Haroon Road  
**KARACHI 0302**  
Tel: 524131, 524132  
Telex: 2894 MUSKO PK  
Cable: COOPERATOR Karachi  
A,E,P\*

#### **PANAMA**

Electronico Balboa, S.A.  
Calle Samuel Lewis, Ed. Alfa  
Apartado 4929  
**PANAMA 5**  
Tel: 64-2700  
Telex: 3483 ELECTRON PG  
CM,E,M,P

#### **PERU**

Cia Electro Médica S.A.  
Los Flamencos 145  
San Isidro  
Casilla 1030  
**LIMA 1**  
Tel: 41-4325, 41-3705  
Telex: Pub. Booth 25306 PEC PISIDR  
CM,E,M,P  
SAMS S.A.  
Arenida Republica de Panama 3534  
San Isidro, **LIMA**  
Tel: 419928/417108  
Telex: 20450 PE LIBERTAD  
A,C,P

#### **PHILIPPINES**

The Online Advanced Systems Corp.  
2nd Floor, Electra House  
115-117 Esteban Street  
Legaspi Village, Makati  
Metro **MANILA**  
Tel: 815-38-10 (up to 16)  
Telex: 63274 ONLINE PN  
A,C,E,M,P

#### **PORTUGAL**

Mundinter Intercambio  
Mundial de Comércio S.A.R.L.  
Av. Antonio Augusto Aguiar 138  
Apartado 2761  
**LISBON**  
Tel: (19) 53-21-31, 53-21-37  
Telex: 16691 munter p  
M  
Soquimica  
Av. da Liberdade, 220-2  
1298 **LISBOA** Codex  
Tel: 56-21-82  
Telex: 13316 SABASA  
A

Telectra-Empresa Técnica de  
Equipamentos Eléctricos S.A.R.L.  
Rua Rodrigo da Fonseca 103  
P.O. Box 2531  
**LISBON 1**  
Tel: (19) 68-60-72  
Telex: 12598  
CM,E  
C.P.C.S.I.  
Rua de Costa Cabral 575  
4200 **PORTO**  
Tel: 499174/495173  
Telex: 26054  
C,P

#### **PUERTO RICO**

Hewlett-Packard Puerto Rico  
101 Muñoz Rivera Av  
Esu. Calle Ochoa  
**HATO REY**, Puerto Rico 00918  
Tel: (809) 754-7800  
A,C,CM,M,E,P

#### **QATAR**

Computer Arabia  
P.O. Box 2750  
**DOHA**  
Tel: 428555  
Telex: 4806 CHPARB  
P  
Nasser Trading & Contracting  
P.O. Box 1563  
**DOHA**  
Tel: 422170  
Telex: 4439 NASSER DH  
M

#### **SAUDI ARABIA**

Modern Electronics Establishment  
Hewlett-Packard Division  
P.O. Box 281  
Thuobah  
**AL-KHOBAR 31952**  
Tel: 895-1760, 895-1764  
Telex: 671 106 HPMEEK SJ  
Cable: ELECTA AL-KHOBAR  
C,E,M





# SALES & SUPPORT OFFICES

Arranged alphabetically by country

## SAUDI ARABIA (Cont'd)

Modern Electronics Establishment  
Hewlett-Packard Division  
P.O. Box 1228

Redec Plaza, 6th Floor

### JEDDAH

Tel: 644 96 28

Telex: 4027 12 FARNAS SJ

Cable: ELECTA JEDDAH

A,C,CM,E,M,P

Modern Electronics Establishment

Hewlett-Packard Division

P.O.Box 22015

### RIYADH 11495

Tel: 491-97 15, 491-63 87

Telex: 202049 MEERYD SJ

C,E,M

Abdul Ghani El Ajou Corp.

P.O. Box 78

### RIYADH

Tel: 40 41 717

Telex: 200 932 EL AJOU

P

## SCOTLAND

See United Kingdom

## SENEGAL

Societe Hussein Ayad & Cie.

76, Avenue Georges Pompidou

B.P. 305

### DAKAR

Tel: 32339

Cable: AYAD-Dakar

E

Moneger Distribution S.A.

1, Rue Parent

B.P. 148

### DAKAR

Tel: 215 671

Telex: 587

P

Système Service Conseil (SSC)

14, Avenue du Parachois

### DAKAR ETOILE

Tel: 219976

Telex: 577

C,P

## SINGAPORE

Hewlett-Packard Singapore (Sales)

Pte. Ltd.

#08-00 Inchcape House

450-2 Alexandra Road

Alexandra P.O. Box 58

### SINGAPORE, 9115

Tel: 4731788

Telex: 34209 HPSGSO RS

Cable: HEWPACK, Singapore

A,C,E,M,P

Dynamar International Ltd.

Unit 05-11 Block 6

Kolam Ayer Industrial Estate

### SINGAPORE 1334

Tel: 747-6188

Telex: 26283 RS

CM

## SOUTH AFRICA

Hewlett-Packard So Africa (Pty.) Ltd.

P.O. Box 120

Howard Place CAPE PROVINCE 7430

Pine Park Center, Forest Drive

Pinelands

### CAPE PROVINCE 7405

Tel: (021) 53 7954

Telex: 57-20006

A,C,CM,E,M,P

Hewlett-Packard So Africa (Pty.) Ltd.

2nd Floor Juniper House

92 Overport Drive

### DURBAN 4067

Tel: (031) 28-4178

Telex: 6-22954

C

Hewlett-Packard So Africa (Pty.) Ltd.

6 Linton Arcade

511 Cape Road

Linton Grange

### PORT ELIZABETH 6001

Tel: 041-301201

Telex: 24-2916

C

Hewlett-Packard So Africa (Pty.) Ltd.

Fountain Center

Kalkoen Str.

Monument Park Ext 2

### PRETORIA 0105

Tel: (012) 45 5725

Telex: 32163

C,E

Hewlett-Packard So Africa (Pty.) Ltd.

9 Eastern Service Road

Eastgate Ext. 3

### SANDTON 2144

Tel: 802-5111, 802-5125

Telex: 4-20877 SA

Cable: HEWPACK Johannesburg

A,C,CM,E,M,P

## SPAIN

Hewlett-Packard Española, S.A.

Calle Entenza, 321

### 08029 BARCELONA

Tel: 3/322 24 51, 321 73 54

Telex: 52603 hpbee

A,C,E,M,P

Hewlett-Packard Española, S.A.

Calle San Vicente S/N

Edificio Albia II-7B

### 48001 BILBAO

Tel: 4/423 83 06

A,C,E,M

Hewlett-Packard Española, S.A.

Ctra. de la Coruña, Km. 16, 400

Las Rozas

### E-MADRID

Tel: (1) 637.00.11

Telex: 23515 HPE

C,M

Hewlett-Packard Española, S.A.

Avda. S. Francisco Javier, S/N

Planta 10. Edificio Sevilla 2

### 41005 SEVILLA

Tel: 54/64 44 54

Telex: 72933

A,C,M,P

Hewlett-Packard Española, S.A.

Isabel La Católica, 8

### 46004 VALENCIA

Tel: (96) 351 59 44

Telex: 63435

C,P

Hewlett-Packard Española, S.A.

Av. de Zugazarte, 8

Edificio El Abra 4

Las Arenas-Guecho

### VIZCAYA

Tel: (94) 464 3255, 464 2933

Telex: 33032

## SWEDEN

Hewlett-Packard Sverige AB

Östra Tullgatan 3

### S-20011 MALMÖ

Box 6132

Tel: (040) 70270

Telex: (854) 17886 (via Spånga

office)

C,P

Hewlett-Packard Sverige AB

Västra Vintergatan 9

### S-70344 ÖREBRO

Tel: (19) 10-48-80

Telex: (854) 17886 (via Spånga office)

C

Hewlett-Packard Sverige AB

Skalholmsgatan 9, Kista

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